SCIENCE

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The Editorial Board administers policies that are established by the Publications Subcommittee of the Executive Committee of the AAAS. Limitations are automatically imposed by financial considerations, which place restrictions on the number of pages that can be published; and by the character of the manuscripts received. So many of the latter come unsolicited that the composite of solicited and unsolicited articles creates a pattern from which it is difficult to escape, although an earnest effort is made to secure variety by inviting papers in fields that are inadequately represented. If SCIENCE seems to be a biochemical-medical journal, physicists, chemists, geologists, and biologists can readily correct the situation and restore the balance by submitting more papers in their respective fields. The Publications Committee and the Editorial Board will welcome, and cooperate to achieve, this result. We are particularly interested in obtaining scholarly, up-to-date surveys of new developments of interest to scientists in many fields.

Approximately 1500 original manuscripts reach the editorial offices in the course of a year, and of this number less than half can be published. The editors do not impose arbitrary word limits on authors, but they favor articles that are brief and to the point; and so long as space is at a premium, they must restrict acceptance of manuscripts detailing laboratory methods and equipment unless the information imparted is important in a wide area of research. In general, technical papers are printed in order of receipt, but this rule is sometimes set aside to give priority to a paper that seems to possess unusual interest to workers in a certain field.

The effort to improve the journal is unremitting. Since 1951 there has been a substantial increase in the volume and coverage of News and Notes, and in the number of meeting reports. Page 3 and the weekly list of Meetings and Conferences have been added. Currently it is planned to increase the number and broaden the scope of articles of general interest, and to add to the news coverage and to the fields included in the technical papers.

The aim of everyone concerned with SCIENCE is to make it an indispensable American news magazine of world science. Readers and authors are urged to assist in achieving this aim, for it cannot be done unaided by a staff of only four full-time and two part-time employees, who must produce both SCIENCE and THE SCIENTIFIC MONTHLY. There are no reporters covering scientific events; hence it will help if readers will function as reporters—and if authors will become editors to the extent of adopting SCIENCE style and format in the preparation of manuscripts. SCIENCE is not so much what the Editorial Board and the editors would like it to be as what its contributors make it.

HOWARD A. MEYERHOFF
For the Editorial Board

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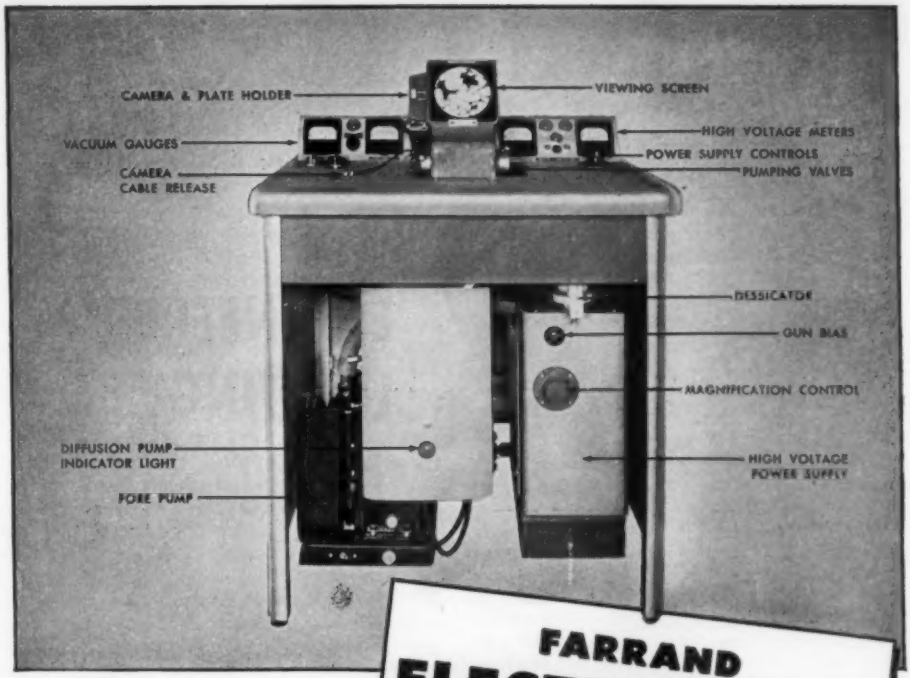

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The Reflectivity of Deciduous Trees and Herbaceous Plants in the Infrared to 25 Microns

David M. Gates and Wirojana Tantraporn[1]

Department of Physics, University of Denver, Denver, Colorado

OF GENERAL INTEREST to the ecologist, plant physiologist, astrophysicist, and biophysicist is the infrared reflectivity of the vegetation covering large areas of the earth's surface. The albedo of the earth is influenced by the vegetated areas of its surface. The energy exchange between the earth's surface, its atmosphere, the sun, and the cosmic cold of outer space depends upon the radiative properties of the vegetation, as well as upon the other constituents of its surface. Solar radiation as it reaches the outer limits of the earth's atmosphere is that of a black body radiator at approximately 6000° K, with a maximum intensity at about 4750 A.

Depending upon the solar altitude—that is, the number of air masses traversed by the solar radiation in reaching the earth's surface—the solar radiation distribution curve is reduced and distorted until the maximum energy may appear as far out as 7200 A. This is a consequence of the scattering and absorption that take place in the atmosphere. On a clear day considerably more than 50 per cent of the solar radiation incident at the earth's surface is contained in the infrared. For large solar zenith angles this percentage increases, often becoming as much as 65 per cent beyond 7600 A. A black body at the temperature of the earth's surface, 288° K, will radiate with an energy peak near 10 μ.

Accurate knowledge concerning the infrared reflectivity, absorptivity, and emissivity of leaves in the 1.0–15.0-μ region is essential for a detailed understanding of the energy exchange in the biosphere. The infrared heat exchange must be taken into consideration in the energy balance between the leaf and its surroundings. The role of infrared radiation with regard to photosynthesis and the opening and closing of stomata appears to be negligible (*1*). It might be supposed that the intense absorption of infrared solar radiation as well as earth radiation would play an important part in the transpiration of water and the subsequent temperature equilibrium of the leaf. The reflectivities of numerous species of the Spermatophyta have been reported for the visible and the photographic infrared regions. Except for Coblentz (*2*), none of the investigators obtained reflectivities beyond the 1.0-μ region.

The present investigations were undertaken to determine the reflectivity of numerous deciduous trees and shrubs beyond the photographic infrared in the region of 1.0–25.0 μ. The infrared radiant source was the Globar, whose radiation was reflected off the leaf surface at the desired angle by means of spherical front-surfaced mirrors and then focused upon the entrance slit of the infrared spectrometer. For the measurements extending from 3.0 to 25.0 μ a double-beam Baird infrared spectrophotometer with a NaCl or KBr prism was used. One beam was replaced by an external Globar, mirror arrangement, and reflecting surface, with the beam entering the instrument through the usual cell well position. The radiation was interrupted to give an a-c signal at the bolometer detector, and the signal was recorded in the standard manner for this instrument. The reflectivity record for each leaf contained a zero line representing no energy in the "sample beam," a 100 per cent line representing the reflection off a front-surfaced plane mirror, and the line of reflected energy itself. A mica filter was inserted into the beam to obtain the correct zero line for radiations beyond 8.0 μ, thereby eliminating the influence of scattered light of shorter wavelengths. The slit widths normally used for this instrument in gas analysis were used here and were automatically opened toward greater wavelength in order to compensate for the energy decrease of the radiation law. The results may be considered as accurate to ± 0.20 per cent, within a 10 per cent fractional probable error. This is principally due to the inherent noise level of the instruments used.

A Perkin-Elmer infrared spectrometer, Model 12C, with NaCl prism, was employed for the determination of the reflectivities in the region 0.9–3.0 μ. Again the leaf reflectivity was compared to that of a front-surfaced plane mirror. Unfortunately, for convenience only, the Globar radiation was incident upon the sample surface at a 78° angle. A constant slit width of 0.1 mm was used. The energy was interrupted periodically by a shutter at the Globar position to allow for a-c amplification and the subsequent recording on a Brown Electronik recorder.

To prevent overheating of the sample during measurements, the beam of radiation was focused, not at the sample surface, but so that the area filled was approximately 3″ × ½″ at an angle of incidence of 65°. Angle of incidence refers to the angle made by the ray with the normal to the surface. Larger leaves could easily accommodate this image, but smaller leaf surfaces had to be cut and fitted together to form a continuous mosaic. Double-sided Scotch tape was

[1] We wish to express our indebtedness to Moras L. Shubert, of the Department of Botany, for many helpful discussions and assistance with identifications.

TABLE 1

THE REFLECTIVITY OF LEAVES IN PERCENTAGE TO INFRARED RADIATION AT 65° ANGLE OF INCIDENCE

Plant species	Wavelength in microns							Comments
	3.0	5.0	7.5	10.0	15.0	20.0	25.0	
Acer saccharinum	3.0	4.0	4.5	5.5	5.0			Maple leaf
Asclepias syriaca	0.5	0.5	0.5	1.0	1.0			Milkweed
Canna generalis	0.7	1.2	2.0	2.2	3.0			
Catalpa speciosa	0.0	0.2	0.2	1.0	1.7			Upper surface
	0.0	0.2	0.2	0.6	1.0			Lower surface
Elaeagnus angustifolia	1.0	1.3	1.3	1.5	2.0			Russian olive, upper surface
	2.0	1.3	1.3	1.5	2.0			Lower surface
Euonymus europaea	0.0	1.0	1.7	2.5	3.0	6.0	5.0	
Helianthus annuus	0.0	0.0	0.0	0.3	0.5			
Nymphaea sp.	1.0	3.0	4.0	7.0	8.0			Water lily
	0.8	1.0	2.0	4.0	6.0			
Opuntia sp.	0.5	1.0	1.4	1.4	1.4			Prickly pear cactus
Parthenocissus quinquefolia	2.8	3.0	3.7	4.5	4.0			Upper surface
	2.8	3.0	3.7	4.5	4.0			Lower surface
Populus alba					4.0	6.5	6.0	
P. deltoides	5.0	6.0	7.0	7.5	7.0			Cottonwood
P. tremuloides var. *aurea*	0.2	0.2	1.4	2.3	3.5			Aspen, green, 11,000′
	0.2	0.2	1.4	2.3	3.5			Aspen, yellow, 11,000′
Quercus robur	2.0	3.0	3.5	4.3	4.0			Oak, shade leaf
	2.0	2.5	3.0	4.2	3.7			Shade leaf
	2.0	2.0	2.0	2.0	2.2			Sun leaf
	2.0	2.0	2.0	2.0	2.4			" "
Rhus glabra	1.0	1.8	1.8	2.5	2.2			Sumac, shade leaf
	1.0	1.5	1.2	2.0	2.2			Sun leaf
Ricinus communis	0.8	2.0	2.6	3.5	4.0			Castor bean
Salix babylonica	4.0	4.7	5.3	7.0	6.0			Willow
Sestuca elatior	1.0	1.0	1.5	2.0	2.0			Grass
Syringa vulgaris	0.8	1.5	2.0	3.0	4.0	6.0	6.0	Lilac
Typha latifolia	1.0	1.0	1.5	2.0	2.0			Cattail
Ulmus americanus	2.2	2.4	2.4	2.4	2.5			American elm
	2.2	3.0	3.0	4.0	4.0			Old, dark elm leaf
	0.5	1.0	1.2	2.3	2.5			Young, light elm leaf
Verbascum thapsus	0.0	0.0	0.0	0.0	0.0			Mullen, hairy surface
Viburnum lantana	2.0	1.5	1.5	2.0	2.0	4.0	5.0	
	1.0	1.0	1.0	1.0	1.5			
Yucca glauca	0.2	0.2	0.5	1.0	1.5			
Citrus limonia	6.0	8.2	14.0	17.0	10.0	11.0	9.0	Lemon leaf
Ficus elastica	4.0	5.0	5.0	6.0	5.5			Rubber leaf, upper surface
	5.5	7.6	8.2	8.7	9.3			
	4.0	6.0	8.0	8.7	9.3			
	6.0	7.0	8.0	9.2	9.4			
	1.0	1.3	2.0	2.5	3.0			Lower surface
	0.5	0.8	2.0	3.5	4.9			" "
Musa paradisiaca var. *sapientum*	2.5	2.5	4.2	5.5	9.0	15.0	15.0	Banana leaf
	1.2	2.5	4.4	6.0	6.0	8.0	7.0	

mounted on a flat metal surface with the leaf sections pressed onto its upper face to form a flat mat surface. The leaves used were freshly cut from woody plants and herbs, mostly from the campus of the University of Denver (altitude 5372 feet above sea level), or greenhouses in the city. Aspen leaves were obtained at 11,000 feet in the mountains to the west, and *Sasa japonica* leaves were collected at Manhattan, Kansas. This research was conducted during August and September 1951.

Table 1 contains the reflectivities of the leaves of many species at 65° angle of incidence, in percentage relative to mirror reflection as 100 per cent. As an indication of the functional dependence of the reflectivity on the angle of incidence, a few determinations were made at a 20° angle. These are given in Table 2. Of course all angles are realized in practice. Separate listings for the same species always refer to individual leaves, except where both the upper and lower surfaces were tested. The infrared reflectivities beyond 1.0 μ are generally uninterrupted by any abrupt changes, appearing to have a very slight maximum in the 10-μ region. The rise reported by many authors at 0.72 μ has dropped to a low value again by 3.0 μ. In contrast to the work of Obaton (*3*) on the reflectivities of plants in the near photographic infrared, we have noticed no systematic distinction differentiating the reflectivities of plants native to the Denver region in one ecological situation from those in an-

TABLE 2

THE REFLECTIVITY OF LEAVES IN PERCENTAGE TO INFRARED RADIATION AT 20° ANGLE OF INCIDENCE

Plant species	Wavelength in microns							Comments
	3.0	5.0	7.5	10.0	15.0	20.0	25.0	
Catalpa speciosa	0.0	0.0	0.0	0.7	2.0			
Euonomous europaea					2.0	4.0	4.5	
Populus alba	0.3	1.0	1.8	2.0	2.0	3.0	3.5	
P. deltoides	1.5	1.5	2.0	3.0	3.0	3.8	3.5	
Syringa vulgaris	0.5	1.0	1.0	2.0	3.0	4.0	3.5	Lilac
Ulmus americana	0.5	1.0	1.5	2.0	4.0	4.3	3.2	American elm
Citrus limonia	3.0	3.0	3.5	4.5	6.0			
Ficus elastica	1.0	1.0	2.5	3.0	4.0			
Musa paradisiaca var. *sapientum*	0.3	1.0	1.5	2.5	3.0			

other, although this feature was not extensively explored. The tropical vegetation from the greenhouses possessed greater reflectivities than the native flora. Obaton obtained twice as much reflectivity from mountain flora as from flora of the plains. Billings and Morris (*4*) report on the monochromatic reflectance from 400 mμ to 1100 mμ, as measured by means of a Beckman DU spectrophotometer from the upper leaf surfaces of 20 species of plants selected from five environments in the Western Great Basin. To quote:

> The environments ranged from the desert to an open subalpine slope through three distinct wooded stations. Averages showed that the desert species reflected the greatest amount of visible radiation, followed by subalpine, west-facing pine forest, north-facing pine forest, and shaded campus species in that order. In the infrared, the differences between groups were not so marked, but the greatest reflectance here also was shown by the desert species, with an average value of about 60 per cent.

The reflectivities of leaves given by Pokrowski (*5*), Shull (*6*), and Clark (*7*) show for the visible and photographic infrared that the lower surface of the leaf reflects considerably more than the upper surface, presumably because of the lack of the palisade cells on the lower side. Table 3 gives the ratio of the reflectivity of the upper surface to that of the lower surface for several leaves at 78° angle of incidence. This shows the consistently higher reflectivity of the upper surface with respect to the lower. The single exception to the upper: lower ratio being greater than unity was for *Rhoeo discolor,* in which the upper epidermis is clearly giving rise to the normal green appearance, whereas the lower epidermis contains a deep-red anthocyanin pigment. Microscopic examination revealed the upper surface to be only slightly smoother than the lower. The curves given by Clark show a switching over of the reflectivity curves of the upper and lower surfaces for Swiss chard, *Cinchona succirubra,* and *Hevea brasiliensis* in the region of 7200 A. For many plant leaves this switching over does not occur until farther out, as evidenced by the single value less than unity for *Acer saccharinum* at 1.2 μ.

Inversion of the reflectivities can be understood when one considers the possible mechanism involved.

TABLE 3

RATIO OF THE REFLECTIVITY OF THE UPPER TO THE LOWER LEAF SURFACE

Plant species	Wavelength in microns				
	1.2	1.6	2.0	4.2	5.6
Acer saccharinum	0.7	2.5	3.5	4.4	2.8
Catalpa speciosa			3.5	5.1	4.7
Ficus elastica	2.6	3.2	2.9	1.9	1.5
Populus deltoides		1.7	2.2	2.5	2.3
Quercus robur	3.7	2.0	2.7	2.1	1.8
Salix babylonica		1.4	1.3	1.3	1.1
Sasa japonica		3.5	3.2	2.4	2.2
Tilia americana		3.3	3.3	5.4	10.0 or greater

Willstätter and Stoll (*8*) described the process by which visible and near infrared radiations are reflected internally in a leaf. The radiations are transmitted by the epidermal and palisade layers, and are internally reflected and scattered in the cells of the spongy parenchyma, thereby returning some of the rays toward the outside. Chlorophyll is very transparent in the red and photographic infrared, permitting the penetration of the rays to the spongy parenchyma, where the relationship of cellular structure and air-filled interstices permits the proper reflection of the rays at angles of incidence greater than the critical angle on the internal cell walls. Rabideau, French, and Holt (*9*) reported on the absorption and reflection spectra of leaves, chloroplast suspensions, and chloroplast fragments, as measured in an Ulbricht Sphere in the spectral range 400–800 mμ. They show clearly the correlation between absorption minima for the leaf and the reflection maxima, further substantiating the belief that the radiations in this portion of the spectrum penetrate into the parenchyma cells before returning to the outside.

In order to isolate the boundaries at which the reflection takes place, it was desired to separate the epidermis from the parenchyma, and then to determine the transmissivity and reflectivity of the epidermis and of the underlying parenchyma. The only epidermis readily available of a size for our instrumentation that could be easily stripped off was that from a *Bryophyllum* plant. The transmissivity of the

TABLE 4

PERCENTAGE REFLECTION AND TRANSMISSION OF *Bryophyllum* LEAF AND EPIDERMIS

	Wavelength in microns			
	1.43	2.0	4.2	5.6
Reflection from leaf at 78°	5	7	12	12
" " parenchyma at 78°	2	2	4	4
" " epidermis at 78°	5	7	9	8
Transmission of epidermis	26	41	48	47

epidermis 15 μ thick was of the order of 40 per cent or more at normal incidence (Table 4). Also shown in Table 4 is that the parenchyma alone, with the epidermis stripped off, reflected two fifths as much as the epidermis at 1.43 μ, two sevenths as much at 2.0 μ, and one half as much at 5.6 μ. Allowing for the transmission of the epidermis after two traversals, this results in about 80 per cent or more of the total reflectivity of the leaf taking place at the outer epidermal surface to radiations in the infrared beyond 1.0 μ. The infrared radiations entering the parenchyma layers are totally absorbed therein, since zero transmission was indicated for all leaves measured beyond 1.0 μ. That this is the expected result is indicated by the numerous absorption bands for chlorophyll and xanthophyll in the infrared beyond 3.0 μ, as reported by Coblentz and Stair (*10*). Furthermore, water absorbs intensely at 1.1, 1.4, 1.9, 2.7, and 6.3 μ.

A layer of waxy cuticle on the leaf surface will greatly enhance the reflectivity at the outermost surface. Inspection under a microscope with strong side illumination reveals the details of the leaf surface. Invariably, leaves of high reflectivity, such as *Ficus elastica, Citrus limonia,* and *Populus deltoides,* showed the cutin producing a smooth surface over the bead-like protrusion of the epidermal cells. Often the cuticle layer itself will have a jagged or granulated appearance. If the cuticle is thin or entirely lacking, the surface may have the contour formed by the epidermal cell walls. The degree of roughness or smoothness will be the determining factor governing the reflectivity of the infrared wavelengths beyond 1.0 μ. The upper surface of *Quercus robur* is smoothly contoured, broken up only by the venation, whereas the lower surface is finely granulated, reduced in reflectivity by a factor of 2.0 or more.

Additional information strengthening the thesis that the infrared reflection occurs principally at the outer epidermal surface resulted from the observation that young, light-green elm leaves reflected less than old, dark-green elm leaves, in contradiction to the opposite for visible radiation. Furthermore, the comparison of green and yellow leaves of *P. tremuloides* from 11,000 feet altitude showed no differences in reflectivity, indicating that the radiations do not penetrate enough to be appreciably affected by the pigmentation of the parenchyma. Shull (*6*) has clearly shown that these factors definitely influence the reflectivity in the visible region. The measurements on *Q. robur* and *Rhus glabra* listed in Table 1 show the shade leaf to reflect more than the sun leaf. The shade leaves were thinner, lighter in color, smaller, and of smoother surface than the sun leaves.

A fine pubescence on a leaf surface may either enhance or diminish its reflectivity. In general, if a leaf surface without hairs has a high reflectivity, then the presence of hairs will most probably diminish the reflectivity. At times this can appear misleading, because the human eye compares the relative brightness of the hairs as against the brightness of the surface. The illusion is that, although each hair reflects a relatively large amount of energy per unit area per unit solid angle toward the observer, thus appearing very bright, the reflecting surface is small, so that the total energy reaching the eye is small. In general, the hairs will scatter the radiation and trap it within the hairy blanket. This mechanism is apparently more effective in the infrared than in the visible. The extreme case of *Verbascum thapsus* possessed zero reflectivity, and that for *Asclepias syriaca* was very low. Billings and Morris (*4*) showed a high reflectivity in the visible for *Eurotia lantana,* and a diminished reflectivity in the infrared relative to that for other leaves from the same environment. The upper and lower surfaces of *Elaeagnus angustifolia* (Russian olive) possessed the same reflectivities in our measurements. In visible light the upper surface appears green and the lower silvery. The silvery appearance of the lower surface is due to thousands of small hairs in the form of closely overlapping pin wheels.

The reflectivity of leaves in the infrared beyond 2.0 μ is generally small, being less than 10 per cent for an angle of incidence of 65°, and less than 5 per cent for an angle of 20°. The reflection takes place principally at the outer epidermal surface, with about one fifth or less of it contributed by the epidermal-palisade boundary. The upper surface reflects more than the lower, old leaves more than young, and the shade leaf more than the sun leaf. For each of these the inverse is true in the visible. The structure of the leaf surface and the covering by the cuticle appear to be the factors determining the reflectivity. The transmissivity of leaves is zero in the infrared beyond 1.0 μ, although the transmissivity of the clear epidermis is 40 per cent or more.

References

1. DUGGAR, B. M. *Biological Effects of Radiation,* Vol. II. New York: McGraw-Hill, Chap. 22, 25 (1936).
2. COBLENTZ, W. W. *Natl. Bur. Standards (U. S.),* Bull. No. 9, 283 (1913).
3. OBATON, F. *Compt. rend.,* **212**, 621 (1941); **218**, 721 (1944).
4. BILLINGS, W. D., and MORRIS, R. J. *Am. J. Botany,* **38**, 327 (1951).
5. POKROWSKI, G. I. *Biochem. Z.,* **165**, 420 (1925).
6. SHULL, C. A. *Botan. Gaz.,* **87**, 583 (1929).
7. CLARK, W. *Photography by Infrared,* 2nd ed. New York: Wiley, 255 (1949).
8. WILLSTÄTTER, R., and STOLL, A. *Untersuchungen über Chlorophyll.* Berlin: Springer (1913); English trans. by F. M. Schertz and A. R. Merz (1928).
9. RABIDEAU, G. S., FRENCH, C. S., and HOLT, A. S. *Am. J. Botany,* **33**, 769 (1946).
10. COBLENTZ, W. W., and STAIR, R. *Phys. Rev.,* **33**, 1092 (1929).

News and Notes

Scientists in the News

Otis L. Anderson has been appointed chief of the Bureau of State Services, Public Health Service, succeeding Joseph W. Mountin, who died suddenly on Apr. 26. A former associate chief of the Bureau of Medical Services, Dr. Anderson will direct the federal-state and interstate programs of the service, including administration of the Communicable Disease Center at Atlanta, Ga.; the Environmental Health Center, Cincinnati; and the Arctic Health Center, Anchorage, Alaska.

Charles W. Ballard, dean of Columbia University's College of Pharmacy, will retire July 1 and will be succeeded by **E. Emerson Leuallen.** Dr. Ballard was guest of honor at an awards dinner given by the College of Pharmacy Alumni Association, which presented him with its 1952 award for service to the college. Semicentennial certificates were given to 39 of the college's graduates as another feature of the dinner.

Carl W. Borgmann, dean of faculties at the University of Nebraska, has been named president of the University of Vermont. He will succeed **William S. Carlson,** who became president of the State University of New York Apr. 1. Dr. Borgmann was a member of the technical staff of Bell Telephone Laboratories from 1927 to 1931, assistant professor of chemical engineering at the University of North Carolina, and head of the Engineering Department at the University of Colorado from 1943 to 1947.

William Mansfield Clark, professor of physiological chemistry in The Johns Hopkins University School of Medicine, presented the 1952 Remsen Memorial Lecture of the American Chemical Society's Maryland Section. The Remsen Lectureship was established in 1946 in memory of Ira Remsen, first professor of chemistry at Johns Hopkins and second president of the University. Dr. Remsen was president of the American Chemical Society in 1902. Dr. Clark spoke on "Some Reflections on the Coupling of Chemical Processes and Biochemical Implications."

The first award of the K. C. Li Medal for meritorious achievement in advancing the science of tungsten has been made to **William David Coolidge,** director emeritus of the General Electric Research Laboratory in Schenectady and x-ray consultant to the company. Now 78 years old, Dr. Coolidge retired in 1944 as a vice president and the director of research for G-E. The Li Award, consisting of a gold medal and $1000, will be given every two years. Mr. Li, who discovered tungsten in China, is chairman of the board of the Wah Chang Corporation, a firm which produces and processes tungsten products.

Lloyd W. Daly has been appointed dean of the College of Arts and Sciences of the University of Pennsylvania, effective July 1. Dr. Daly, who is now vice-dean of the university's Graduate School, will succeed **Glenn R. Morrow,** who has received a Guggenheim fellowship to study in Athens during the 1952–53 academic year.

John O. Eichler, professor of civil engineering at the Cooper Union School of Engineering, New York, has been made head of the newly formed Metropolitan New York Section of the American Society of Photogrammetry. Professor Eichler was one of the organizers of the section, which has just received its charter from George D. Whitmore, president of the national society in Washington, D. C.

Benjamin F. Fairless, president of U. S. Steel, was selected by the John Fritz Medal Board of Award to receive the 1953 John Fritz Medal and Certificate as "champion of the American free enterprise system for notable industrial achievement in the production of steel." The John Fritz Medal was established in 1902 by friends of John Fritz on the occasion of his eightieth birthday to honor him for his great contributions in the manufacture of steel and in the advancement of industry generally. It is perpetuated by the American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Mechanical Engineers, and American Institute of Electrical Engineers, as a joint honor for scientific or industrial achievement in any field of pure or applied science, without restriction on account of nationality or sex.

Frank H. Forrester has resigned as supervisor of guest relations and meteorologist at the Hayden Planetarium, effective May 31.

John F. Fulton, the first president of the Association of Honorary Consultants to the Army Medical Library (1944–47), has been elected president of the American Association of the History of Medicine. At the annual meeting of the association in Kansas City, **Benjamin Spector** gave the Fielding H. Garrison Lecture, "The Growth of Medicine and the Letter of the Law."

Katharine R. Jeffers has been appointed dean of Jackson College, the women's department at Tufts College. She will succeed **Edith L. Bush,** sister of Vannevar Bush, who retires at the close of the current academic year. Dean Jeffers has been dean of women and professor of biology at the College of William and Mary since 1947.

Robert F. Johnson, of the U. S. Geological Survey, is attending the Point IV orientation course at the Department of State in preparation for a forthcoming assignment to Peru as a member of a Geological Survey party. **David A. Andrews,** of the

Foreign Geological Branch Office, USGS, arrived in Washington after more than three months in Thailand; and **George M. Lawshe,** topographical engineer, has returned after an assignment of approximately 18 months under the ECA geological survey program in the British Commonwealth.

Charles F. Kettering, a past president of the AAAS, has received the Jefferson Medal from the New Jersey Patent Law Association. The second annual award of the organization, the tribute was in recognition of Mr. Kettering's "many outstanding contributions to the welfare of the nation by his advancement of science, invention, and the American patent system."

Stephen Laufer, director of brewing technology of Schwarz Laboratories, has been elected president of the American Society of Brewing Chemists. Dr. Laufer has been actively engaged in the affairs of the ASBC since it was founded in 1934.

Directors of the International Nickel Company of Canada, Ltd., have elected **Paul D. Merica** president, succeeding **John F. Thompson,** who became board chairman in February 1951, upon the death of **Robert C. Stanley.** Dr. Merica, formerly executive vice president and a director, was first associated with the company in 1919, becoming director of research and subsequently assistant manager of the development and research department. He became vice president in 1936 and executive vice president in 1949.

Raymond C. Moore, of the University of Kansas and past chairman of Section E, AAAS, who was selected by the Association of American Universities and representatives of the Dutch universities as visiting professor in the Netherlands during the current academic year and assigned to the Rijks-Universiteit te Utrecht, has been invited for short-term lectureships at the Sorbonne in Paris, the universities of Louvain and Liége in Belgium, and the universities of Lund in Sweden and Oslo in Norway. Recently he was elected Membre Correspondant of the Société Geologique de Belgique and a Foreign Member of the Geological Society of London.

Charles Edwin Odegaard, executive secretary of the American Council of Learned Societies, has been appointed dean of the College of Literature, Science and the Arts at the University of Michigan. Dr. Odegaard succeeds **Hayworth Keniston,** who in his last year before retirement furlough has been devoting full time to teaching romance languages at his own request. Since Sept. 15, **Burton Thuma,** associate dean, has served as chief administrative officer of the college. Dr. Odegaard will assume the deanship on Sept. 1.

Edith H. Quimby, of the Department of Radiology, College of Physicians and Surgeons, Columbia University, has been awarded the second Jagadish Bose Memorial gold medal by the Indian Radiological Association. Her memorial lecture was entitled "Recent Developments in Radiation Dosimetry."

Herbert H. Ross, of the Illinois Natural History Survey, will visit in seven European countries and will confer with foreign specialists in the study of caddis flies. Recipient of a Guggenheim fellowship awarded to him in 1951, Dr. Ross will spend the major part of his time in Hamburg, and at the British Museum. The project for study under his fellowship is "the evolution of primitive caddis flies in relation to intercontinental mountain chains."

Reinhold Rudenberg, Gordon McKay professor of electrical engineering at Harvard University, has left for Brazil and Uruguay, where he has been invited to deliver a series of lectures on modern topics in electrical engineering. During May and June he is lecturing at the University of Rio de Janeiro and the University of São Paulo in Brazil and the University of Montevideo in Uruguay. Professor Rudenberg is the inventor of the electron microscope and has been awarded the Swedish gold Cedergren Medal and Scroll for highly meritorious work in the field of electrical engineering.

The fifth World Health Assembly, legislative body of the World Health Organization, unanimously elected **Juan Salcedo,** Philippines secretary of health, as its president. The assembly, at which 60 member-states are represented, elected as vice presidents the chief delegates from Switzerland, Haiti, and Liberia. The outgoing president is **Leonard A. Scheele,** U. S. surgeon-general.

Joshua L. Soske, of the Geophysical Engineering Corporation, will occupy the Henry Salvatori associate professorship in geophysics at Stanford University. The Salvatori chair has been made possible by a gift from Henry Salvatori, president of the Western Geophysical Company, of Los Angeles. Mr. Salvatori is also the donor of equipment for Stanford's new geophysical laboratory.

Eugene A. Stead, chairman of the Department of Medicine at Duke Medical School, has been elected president of the American Society for Clinical Investigation for 1952–53, and **James V. Warren,** professor of medicine at Duke, has been elected president of the American Federation for Clinical Research at a joint meeting of the society and the federation. Dr. Stead was formerly dean of Emory University Medical School, and Dr. Warren was medical investigator, Office of Scientific Research and Development, on problems of shock and vascular injuries.

George P. Thomson, at present chairman of the Physics Department of Imperial College, University of London, has been appointed Master of Corpus Christi College, Cambridge, of which he is a member. He will take up his new position this summer.

T. Thorvaldson, of Saskatoon, and **W. H. Watson,** of Toronto, have been appointed new members of the National Research Council for three years starting April 1. Dr. Thorvaldson is dean of graduate studies

emeritus at the University of Saskatchewan, and Dr. Watson is head of the Department of Physics at the University of Toronto. Two other members, who have served one term each, have been reappointed for a second term of three years. They are: **J. H. L. Johnstone,** of Halifax, N. S., and **F. C. Wallace,** of Oshawa and Georgetown, Ont. **C. J. Mackenzie,** who recently resigned from the presidency, has been reappointed as a member of the Honorary Advisory Council for Scientific and Industrial Research (the full title of the National Research Council). With these appointments the council now consists of President E. W. R. Steacie, David A. Keys, vice president (scientific), E. R. Birchard, vice president (administration), and 17 other members.

J. C. Walker, professor of plant pathology, University of Wisconsin, returned recently from Brazil, where he was visiting lecturer in plant pathology at the Biological Institute, State of São Paulo, São Paulo.

Ray L. Watterson, associate professor of biology at Northwestern University, has been awarded the first Frank R. Lillie fellowship in experimental embryology to do research at the Marine Biological Laboratory in Woods Hole, this summer. The fellowship has just been created by the family of the late Frank R. Lillie, experimental embryologist, who died in 1947. Dr. Lillie was at one time president of both the Marine Biological Laboratory where Watterson will work, and also president of the nearby Woods Hole Oceanographic Institution. Dr. Watterson plans to do experiments with fish eggs which may bear out the contention that the vertebral column and the skull are stimulated to form in the embryonic stages by the presence of the spinal cord or brain, or embryonic induction.

Education

The following visiting lecturers will give courses at **Harvard University** during the 1952–53 fall term: Walter H. Brattain, of Bell Telephone Laboratories, one of the co-inventors of the transistor; Sydney Goldstein, of the College of Technology, Haifa; and W. Duncan Rannie, of the Department of Mechanical Engineering, Caltech.

The **Institute of Gas Technology,** affiliated with Illinois Institute of Technology, has named E. S. Pettyjohn vice president, the first in its history. J. D. Parent has been made dean, and Henry R. Linden and C. G. von Fredersdorff assistant research directors. Captain Pettyjohn succeeded to the directorship of the institute in 1945 while he was still on duty with the U. S. Navy. His subsequent appointment as vice president was made in recognition of his contribution to the institute's rise to its present position in research and education.

State University of New York College of Forestry at Syracuse has established a professorship of physical and polymer chemistry; research in the field was begun in 1948, and in 1949 senior and graduate training in plastics technology was established. Michael Szware, of the University of Manchester, was appointed the first professor, and took up his new duties on June 2.

The **University of Texas** Medical Branch is holding a weekly series of seminars, May 27 to July 15, on molecular cell physiology. The seminars are held on Tuesdays at noon in the Carter Physiology Laboratory and are open to physicians and graduate workers.

The **University of Utah** reports that John Z. Bowers, dean of the College of Medicine, will serve in India for two months as a consultant on health education to the Ford Foundation. M. M. Wintrobe has been named chairman of the Advisory Council of the Life Insurance Medical Research Fund for 1952–53. Don H. Nelson, of the Department of Biochemistry, recently reported some of the results of his work, at the Ciba Conference in London; Stewart Harvey, assistant professor of pharmacology, has been made a Markle Scholar in Medical Science. Glen R. Leymaster, head of the Department of Public Health and Preventive Medicine, has returned from a trip sponsored by the Rockefeller Foundation for the study of out-patient medical teaching in various U. S. schools and clinics. The results of his study will be made available to medical schools throughout the country.

Grants and Fellowships

The **American Philosophical Society** will accept applications at any time for grants-in-aid of expenses for research in the physical, biological, and social sciences, and the humanities. The Committee on Research meets in October, December, February, April, and June and considers all applications received up to one month prior to the meeting. Full information may be obtained from the executive office of the society, 104 S. Fifth St., Philadelphia 6.

The **Archer-Daniels Midland Company,** of Minneapolis, has established a fellowship for a graduate student majoring in chemistry, at the North Dakota Agricultural College. The grant is for $750 per year. The **Cataphote Corporation,** of Toledo, Ohio, has also established a $2400 fellowship at the school to subsidize basic research at the graduate level in the field of highway traffic paint.

The **Bausch & Lomb Science Scholarships,** awarded each spring, were won by Roy L. Schult, Mary B. Boat, and Paul F. Forman, all of New York. In addition, ten other finalists in the competition were given University of Rochester scholarships of comparable value. High school science students from 11 states were among those competing in the final tests.

The Department of Physiology at **Ohio State University** is offering graduate teaching and research assistantships at $100–$150 per month, plus remission of fees. Application should be made before *July*

15. For forms on which to apply write to the chairman of the department.

In the Laboratories

The **Applied Physics Laboratory** of The Johns Hopkins University has added Philip K. Reily, Jr., to the staff of the Solid Propellant Information Agency staff. He was formerly a research chemist with the Ohio Apex Corporation, Nitro, W. Va. Robert M. Moyerman, former chemist with Nuclear Development Associates, has joined the Research Center at the laboratory.

The **James Forrestal Research Center,** established in January 1951 as a memorial to the first Secretary of Defense, was formally dedicated May 17. Robert A. Lovett was the principal speaker. Most fully developed research programs at present are in aeronautical, jet propulsion, and chemical engineering. Daniel C. Sayre is director of the center.

A vinyl plastic plant built by the **Japanese Geon Company, Ltd.,** in cooperation with B. F. Goodrich Chemical Company, has begun production at Kambara, near Tokyo. Engineering design and manufacturing techniques were furnished, and the construction supervised, by Goodrich.

Wallace L. Howe, director of development, has been appointed director of research and development of the **Norton Company,** following the resignation of Samuel S. Kistler, who has been a member of the research staff for nearly 17 years.

The new $4,000,000 **Sharp & Dohme** Medical Research Laboratories at West Point, Pa., were dedicated May 12. As a part of the program a symposium on "Frontiers of Research on Blood and Plasma Extenders" was presented, with I. S. Ravdin as moderator. Members of the panel were Carl W. Walter, Charles A. Janeway, Charles S. Davidson, Douglas M. Surgenor, Edwin J. Pulaski, and Robert B. Pennell.

Meetings and Elections

The **Arkansas Academy of Science** has named Delbert Swartz president, Z. V. Harvalik vice president, and William J. Smothers secretary-treasurer. The Junior Academy elected Jim Davidson, of Helena, president. Six high school seniors were honored by the two academies after having been selected as winners in the first annual Arkansas Science Talent Search. Hilary Linder, of Subiaco Academy, was presented with a scholarship to the University of Arkansas as the outstanding young scientist of the year.

Central States Section, **Botanical Society of America,** has completed plans for an August foray in the Lake Okoboji region, during which the annual meeting and election of officers will also be held. Registration will begin at Iowa Lakeside Laboratory, Milford, Aug. 17, and during the following three days several aquatic and prairie locales will be visited. Registrants will be given a complete itinerary, and papers on the flora of the area. Inquiries and requests for reservations should be addressed to H. S. Conard at the Lakeside Laboratory.

At the annual meeting of the **Hawaiian Academy of Science** in May, Harry L. Arnold, Jr., was elected president, succeeding L. D. Baver. Doak C. Cox replaced E. H. Bryan, Jr., as secretary-treasurer. Dr. Baver's presidential address was on "The Rise and Fall of Peruvian Culture." Membership in the academy is now 344, largest in its history.

The **Rocky Mountain Biological Laboratory,** located near Crested Butte, Colo., in the Gunnison National Forest, will celebrate its 25th anniversary on Aug. 2. Reseeding and grazing problems in the high Rockies will be discussed at the morning session and parasites of wild and domesticated mammals and birds of the West at the afternoon session. George W. Hunter III will give the principal address at noon on "Parasitic Problems of the U. S. Army in Korea and Japan." Zoologists and botanists are invited to attend the morning and afternoon programs, and to be guests at the mountain trout picnic dinner at noon. There are paved roads to within 15 miles of the laboratory.

Miscellaneous

At its annual meeting Apr. 22, the **Joseph A. Holmes Safety Association** awarded Medals of Honor for individual deeds of heroism in saving life in mines and plants of the minerals industry during the past year to Dangel Lancaster, W. L. Laxton, Charles F. Wesche, E. L. Colvin, George Pejko, Jr., J. J. Sullivan, William W. Fillip, and Rayburn W. Bunton. More than 400 awards were made for exceptional safety records and outstanding supervisory work. R. G. Warncke, Bureau of Mines, was elected secretary to succeed J. J. Forbes, who became president last year.

Top awards in the third annual **National Science Fair** went to Doris Jean Hermes, of Martinsville, Va.; Raymond P. Oberly, of Allentown, Pa.; Gretchen Koosmann, of Los Angeles; and Elton Stubblefield, of Fort Worth. Fourteen scientific equipment and book awards are given each year in the nationwide contest, which is conducted by Science Service in cooperation with metropolitan newspapers in all parts of the country.

Victor B. Scheffer, U. S. Fish and Wildlife Service biologist in charge of the Alaska fur-seal investigations, wishes to correspond with an advanced student interested in describing the anatomy of the fur seal as material for a doctoral thesis. His address is 2725 Montlake Blvd., Seattle 2, Wash.

CORRECTION: In the announcement concerning the third **International Congress of Electroencephalography and Clinical Neurophysiology** on page 458 of the April 25 issue of SCIENCE, the year was inadvertently omitted. The meeting will be held Aug. 18–21, *1953*, in Boston.

Technical Papers

Influenza Virus Proliferation in Hypoxic Mice[1]

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It has been demonstrated that experimental manipulation of the rate of protein anabolism in the host cell is reflected by alterations in rate of influenza virus growth. When protein anabolism is stimulated by the administration of testosterone or pituitary growth hormone to the host, virus growth is enhanced (*1*). On the other hand, when the dynamic equilibrium of protein metabolism is disturbed in favor of catabolic processes, as in castration of male mice and in ACTH and cortisone administration, the rate of virus growth is diminished (*2*).

In order to study further the impact of alterations in the metabolism of the mammalian host cell on virus proliferation, experiments have been done on the rate of growth of influenza virus in mice rendered hypoxic in a decompression chamber. It is well known that the synthesis of tissue protein requires an expenditure of energy, and that if the energy-yielding oxidative reactions in cells are acutely compromised, tissue catabolism exceeds anabolism and an excess of nitrogen is excreted in the urine. If the intricate syntheses involved in virus reproduction require coupled host cell oxidative mechanisms as a source of energy, a sudden impairment in the efficiency of those mechanisms would interfere with the ability of virus particles to reproduce. The present study is concerned with an exploration of this possibility.

Groups of 10 mice were inoculated intranasally with approximately 1000 LD_{50} of influenza virus under light ether anesthesia. Upon recovery from the anesthetic the mice were separated into two groups of 5; one group was kept in a small cage at sea level barometric pressure, and the other was placed in a well-ventilated vacuum desiccator type of decompression chamber. Water and food pellets were given to both groups *ad lib*. Within 15 min after virus inoculation the decomposition chamber was evacuated to a simulated altitude of about 30,000′, which is approximately equivalent to an oxygen partial pressure of 6.5% (*3*). At the end of the designated time for each experiment the pressure in the chamber was permitted to rise, the mice were sacrificed, and their lungs removed for estimation of virus growth.

In a preliminary series of experiments done on pooled lungs of groups of 5 mice exposed to low barometric pressure for 3, 6, 9, 12, 15, 18, 21, and 24 hr after inoculation it was found that the experiments performed at the 15-hr interval most consistently showed a difference in virus growth between the hypoxic groups and the control groups. Therefore, the experiments reported here were done at 15 hr after virus inoculation.

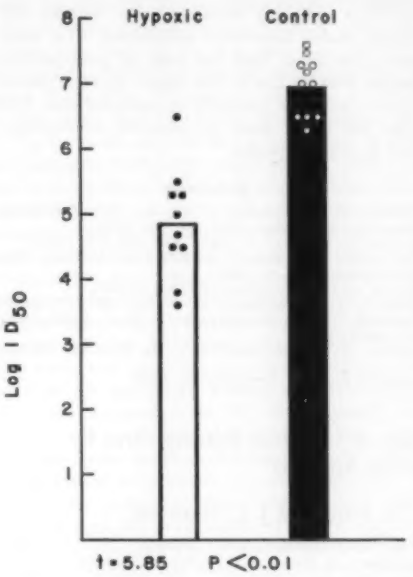

FIG. 1. The growth of influenza virus in hypoxic and control mice after 15 hr.

The data shown in Fig. 1 were obtained on two occasions when 11 mice were made hypoxic and 11 served as controls. Only one of the hypoxic mice failed to survive decompression. Each of the remaining 21 is considered as an individual, for each pair of lungs was removed, homogenized in a chilled Waring blendor, and titrated *in ovo* (*4*). At least 4 eggs per dilution were used for each pair of mouse lungs. The presence or absence of virus was determined by the ability of the allantoic fluid of inoculated eggs to agglutinate erythrocytes. The ID_{50} was determined by the method of Muench and Reed (*5*).

The results indicate a growth inhibition of about two logarithmic intervals in the animals subjected to decompression; the mean log ID_{50} for the controls was 6.97 ± SE 0.143, and that for the exposed mice was 4.87 ± SE 0.27. A statistical evaluation of this mean difference revealed a t value of 5.85, and the probability that this result could be due to chance is, therefore, much less than 0.01.

The relationship between oxygen lack and virus proliferation in tissue culture has been known for some time. Zinsser and Schoenbach (*6*) demonstrated that

[1] Aided by a grant from the Hendricks Research Fund.

the rate of Western equine encephalitis virus growth in tissue culture was greatest during maximal oxygen consumption by the host cells. Magill and Francis (7) found that influenza virus in tissue culture did not multiply under anaerobic conditions. The data reported here show that the rate of proliferation of influenza virus is low in the intact hypoxic animal as compared with the normally oxygenated one. Further studies are being done on possible mechanisms involved in this response.

References

1. Kalter, S. S., Stuart, D. C., Jr., and Tepperman, J. *Proc. Soc. Exptl. Biol. Med.*, **74**, 605 (1950).
2. Kalter, S. S., *et al. J. Exptl. Med.*, **93**, 529 (1951).
3. Van Liere, E. J. *Anoxia: Its Effect on the Body.* Chicago: Univ. Chicago Press (1942).
4. Hirst, G. K. *J. Immunol.*, **45**, 285 (1942).
5. Reed, L. J., and Muench, H. *J. Hyg.*, **27**, 493 (1938).
6. Zinsser, H., and Schoenbach, E. B. *J. Exptl. Med.*, **66**, 207 (1937).
7. Magill, T. P., and Francis, T., Jr. *Ibid.* **63**, 803 (1936).

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Assay of Uranium-bearing Ores by Fission Analysis[1]

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The common methods of assaying uranium ore by physical means require a knowledge of the equilibrium condition of the sample, since an error may be introduced because of the partial or complete absence of some of the daughter elements in the radioactive series. An error may also be introduced by radiation caused by thorium or potassium.

The possibility of assaying uranium ore by measuring the fissionable content with neutron-induced fissions was investigated by using a 50 mc Ra-Be neutron source[2] and standard alpha scintillation detection equipment. It was assumed that the fission particles, because of their greater energy, could be distinguished from α-particles by counting only scintillation pulses of large amplitude. In this way a direct indication of the U^{235} content of the ores could be obtained. Although the method was found to be too complicated for routine analysis, it seems worth while to record some of the results obtained.

Observations on the unknown ore samples were carried out with the following arrangement. Neutrons from the Ra-Be source were slowed down by a 3″ wall of paraffin and impinged on the sample, which was mounted directly below the photocathode of a 931A photomultiplier. The only one of several methods of preparing the sample which proved satisfactory consisted of mixing a 50-mg sample of ore containing about 40% uranium oxide with an equal amount of Patterson D phosphor. The mixture was spread as a thin uniform layer on a microscope slide and mixed with a binder of amyl acetate.

The zinc sulphide phosphor is relatively insensitive to β- and γ-radiation, so that the background count above which the fission products had to be detected was due mainly to the α-particles emitted by all the uranium daughter elements in the course of their natural decay. The contribution to the total background due to the phototube dark current and to γ-sensitivity was found to be negligible. It was important to allow a sufficiently long period for the phosphor to reach a steady state after exposure to daylight. The main difficulty in evaluating measurements of this type arose from the fact that the pulse amplitude distribution from the α-particles and fission pulses turned out to be much alike, and that the fission pulse counting rate was rather low because of the weak neutron source used.

Fig. 1 shows the counting rate observed with and without exposure to the neutron source, and with and without a sample. The curves indicate that the change in counting rate observed as a result of fission detection is more pronounced at higher discriminator settings. This difference, though significant and measurable, is rather small considering the high uranium content of the sample.

Some observations were also carried out to check the time dependence of the fission counts, and these results are summarized in Fig. 2, which shows the pulse distribution for various times of irradiation relative to the α-pulse distribution. There was a grad-

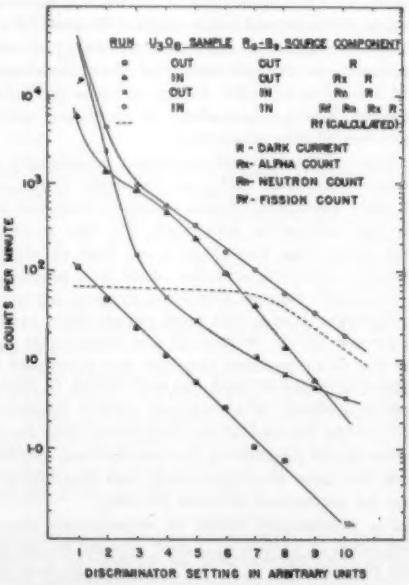

Fig. 1. Scintillation response from uranium-bearing mixture as a result of exposure to the neutron source.

[1] Permission for publication of this work has been granted by the director general of scientific services, Department of Mines and Technical Surveys, Ottawa, Canada.

[2] The loan of the neutron source by the Eldorado Mining and Refining (1944) Ltd., is gratefully acknowledged.

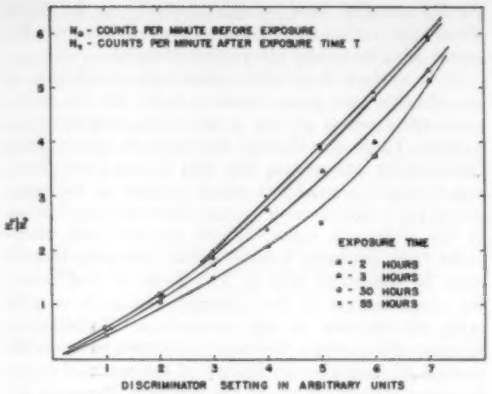

FIG. 2. Differential pulse amplitude distribution and the effect of exposure time on the relative counting rate.

ual increase in activity during the first 24 hr, after which little further increase in activity could be detected. This increase probably represents the gradual approach to equilibrium conditions among the fission products and is due to the extra pulses produced by the recoil of these nuclei and to a lesser extent to the more energetic β-particles associated with them. Similar measurements were carried out with 10% and 1% U_3O_8 samples. For a 10% sample only a small increase in counting rate was observed, whereas no effect was observed for the 1% sample. It appears, therefore, that some useful information concerning the distribution of fission pulses might be obtained by this method, particularly with a stronger source and a more sensitive photomultiplier; for assay purposes, determination of the natural decay radiation is more accurate and convenient.

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Evidence for the Occurrence of Intermediates during Mutation[1]

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A great deal of experimental evidence has been published which demonstrates that environmental factors such as temperature, gas tension, and infrared irradiation can greatly alter the effectiveness of various mutagenic agents (*1, 2*). Much of this evidence suggests that the action of x-ray and ultraviolet radiation on genes and chromosomes is indirect rather than direct and that chemical mutagens are the immediate agents of mutation. Whether the delayed effects of x-ray and ultraviolet radiation depend upon some photochemical product which is produced in the cytoplasm or whether they are due to a slow stabilization of structural alterations in the chromosome induced at the time of irradiation cannot be determined conclusively by supplementary treatments. Previous results concerning the effect of pressure on the mutations induced by nitrogen mustard clearly established the fact that chemical alterations that lead to gene changes are freely reversible for a considerable time after the removal of the mutagenic agent (*3*). These results suggest that a transitory, semiactivated complex is formed which finally decomposes either to the original state or to a new, mutated state. Decomposition to a mutant state apparently proceeds with an increase in volume, since pressure can prevent its occurrence. The results set forth in the present communication also suggest that intermediate activated states are formed by the action of radiation and that it is these activated states that are affected by the supplementary treatments. From the effects of temperature and pressure one must conclude, therefore, that all molecular alterations involved in a change to a mutated form do not necessarily occur simultaneously with the absorption of the radiant energy and that a latent period exists which is affected by temperature or pressure. Swanson and Yost (*4*) have recently published experiments which demonstrate that a similar interpretation can be applied to the effects of infrared irradiation. A theoretical treatment of the subject has been published by McElroy and Swanson (*5*).

A microconidial strain of *Neurospora crassa* (*6*) was used to study the effect of pressure on the mutation rate after exposure to ultraviolet irradiation. Five-day-old conidia were suspended in sterile water and filtered through cotton pads in order to remove mycelial fragments. Samples of the suspension (containing an average of 5×10^6 spores/ml) were placed in a quartz flask, and the latter was attached to a low-speed motor at a distance of 24″ below a Westinghouse sterilamp. During irradiation the suspension was continuously rotated. Immediately after irradiation a sample of the suspension was placed in a sterile rubber balloon, which was then inserted into a pressure bomb, in which the hydrostatic pressure was raised as rapidly as possible to 10,000 psi. From 1 to 2 min always elapsed between the termination of irradiation and the application of pressure. Part of the irradiated suspensions was kept at atmospheric pressure in the sterile quartz flask until the termination of the pressure treatment, which was always for 30 min. At the end of this time both control and pressure-treated suspensions were plated by serial dilution onto a complete medium containing 1.5% *l*-sorbose. After 3–4 days single isolates were transferred to complete slants without sorbose and subsequently scored for morphological mutations. In some experiments the transfers were made to large tubes (16 × 150 mm) containing the complete medium, whereas in others the transfers were made to small tubes (10 × 75 mm). The rate of morphological mutations appears to be somewhat lower on the latter

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TABLE 1

EFFECT OF PRESSURE ON ULTRAVIOLET-INDUCED MUTATIONS IN *Neurospora crassa*. SURVIVAL GREATER THAN 5%

Expt. No.	Treatment	No. isolations	No. morphological mutants	Mutation (%)	Kill (%)
3-18	15′ UV	300	18	6.0	72.1
	15′ UV + 10,000 psi	300	13	4.3	74.4
3-27	15′ UV	289	16	5.5	90.0
	15′ UV + 10,000 psi	299	11	3.7	93.0
3-26	15′ UV	289	17	5.9	84.6
	15′ UV + 10,000 psi	294	10	3.4	90.0
12-15	20′ UV	292	54	18.5	93.3
	20′ UV + 10,000 psi	285	30	10.5	94.1
12-29	20′ UV	300	71	23.7	90.2
	20′ UV + 10,000 psi	200	31	15.5	92.2
2-10	20′ UV	229	42	18.3	94.5
	20′ UV + 10,000 psi	129	22	17.0	95.1

TABLE 2

EFFECT OF PRESSURE ON ULTRAVIOLET-INDUCED MUTATIONS IN *Neurospora crassa*. SURVIVAL LESS THAN 5%

Expt. No.	Treatment	No. isolations	No. morphological mutants	Mutation (%)	Kill (%)
2-1	20′ UV	335	51	15.2	96.3
	20′ UV + 10,000 psi	225	50	22.2	96.5
1-27	20′ UV	200	35	17.5	98.5
	20′ UV + 10,000 psi	200	42	21.0	99.1
11-8	25′ UV	354	78	22.0	98.5
	25′ UV + 10,000 psi	162	49	30.2	99.4
3-6	25′ UV	300	20	6.7	98.9
	25′ UV + 10,000 psi	289	45	15.6	99.5
3-15	25′ UV	294	41	13.9	99.94
	25′ UV + 10,000 psi	153	27	17.7	99.99
3-23	25′ UV	289	12	4.2	99.2
	25′ UV + 10,000 psi	293	21	7.2	99.8
6-24	35′ UV	297	24	8.1	99.8
	35′ UV + 10,000 psi	299	28	9.4	99.9
6-30	35′ UV	306	25	8.2	99.93
	35′ UV + 10,000 psi	300	37	12.3	99.97

slants, since the entire surface of the agar may be covered before certain morphological effects can express themselves.

Preliminary experiments indicated that the effect of high pressure after ultraviolet treatment may lead either to no change, or to an increase or to a decrease in the mutation rate. However, it soon became evident that these changes depend upon the ultraviolet dose as measured by the percentage of survival. The figures presented in Tables 1 and 2 show that at a radiation intensity which results in more than 5% survival (Table 1), pressure reverses the delayed mutagenic action of ultraviolet, whereas at high intensities (less than 5% survival) pressure increases the apparent frequency of mutations. It is significant that the 5% survival level is approximately at the point where the mutation frequency curve begins to decrease with increased ultraviolet dosages.

It is evident that after ultraviolet irradiation a considerable time must elapse in order for the mutagenic effectiveness of this agent to be completely expressed. There are at least two ways in which these facts can be interpreted. The first is that some chemical mutagen is produced which persists in the cytoplasm for a considerable period after the application of the mutagenic agent. If one assumes that ultraviolet light produces some chemical mutagen, then it must be concluded that at low doses of irradiation the concentration of this mutagen results in a high ratio of mutants to the percentage of lethality, whereas at high doses the ratio is lowered, presumably because of increased sensitivity of the mutated types to higher concentrations of the mutagen. Pressure, by preventing the action of the mutagen in the processes leading to mutation and lethality, would affect the mutation-lethality ratio in opposite directions after low and high doses of ultraviolet, respectively. The fact that the difference in response to pressure occurs at the UV dose level where the mutation rate begins to decrease renders the above interpretation plausible. The second interpretation of the above results is based upon the possibility that changes are being induced directly in the chromosome by the absorbed energy, a situation which with time would lead to a mutation or, if the alterations were sufficiently great, to a decrease in viability. It is these alterations in the chromosomes which we refer to as a transitory semiactivated state, a normal intermediate in the mutation process. If the second interpretation is correct, it suggests that the processes leading to mutation and lethality are essentially the same, with the exception that the latter is accompanied by more extensive molecular rearrangements and that the suppression of the latter effect results in an apparent increase in the mutation rate.

An effort has been made, therefore, to obtain evidence that more than one sort of change can occur in the chromosome prior to the mutation event. An experiment was performed to determine whether pressure would have a differential effect on high and low concentrations of nitrogen mustard as mutagenic agents and as supplementary agents in combination with ultraviolet. *Aspergillus terreus* was used, and the procedures were essentially the same as those described for *Neurospora*. In the experiments described, the spore suspension was divided into two parts, one of which was treated for 15 min with ultraviolet and the other with 0.1% nitrogen mustard for 30 min at 25° C. At the end of the two treatments samples were taken from each suspension, diluted, and plated onto complete medium. The remaining mustard-treated sample was centrifuged and washed twice with sterile water and finally divided into two samples. One sample was placed under 10,000 psi for 30 min and the second was maintained at room temperature and pressure for the same period of time. At the end of 30

min, both samples received a 15-min dose of ultraviolet. The samples were then diluted and plated onto complete medium. Isolates from single colonies were subsequently transferred to slants, and after 4 days of growth the morphological mutants were scored. A similar experiment with a higher concentration of nitrogen mustard but without the ultraviolet supplementary treatment was also performed. The results presented in Table 3 clearly indicate that the mutations induced by nitrogen mustard require a lapse of time before they are completely stabilized. Furthermore, the intermediate which is formed apparently decomposes and returns to the original phenotypic state under the influence of high hydrostatic pressure (*cf.* 1, 5, and 6, Table 3). An important point is that this intermediate evidently cannot re-form upon the release of pressure, a fact indicating that the initiating agent is no longer present. Also of interest, however, is the fact that hydrostatic pressure does not eliminate the potentiating effects of the nitrogen mustard upon the ultraviolet-induced mutations. On the contrary, there appears to be a slight stimulatory effect of pressure, such as might be expected for bimolecular reactions (*cf.* 3 and 4, Table 3). The results of this series of experiments suggest that the nitrogen mustard first combines with the chromosome in a reaction which is not depressed by pressure, and that this reaction alters the structure of the chromosome or gene in some way so that it becomes more sensitive to supplementary mutagenic agents such as ultraviolet radiation. If so, this altered structure of the chromosome can itself eventually react in a manner which leads to a considerable molecular rearrangement, resulting in a volume increase and finally decomposing either to the original state or to a mutated state. It is the later reaction which is pressure-sensitive and which decomposes to the original state under high hydrostatic pressure.

TABLE 3

COMBINED EFFECTS OF NITROGEN MUSTARD, ULTRAVIOLET, AND PRESSURE ON MORPHOLOGICAL MUTATIONS IN *Aspergillus terreus*

No.	Treatment	No. isolations	No. mutants	Mutation (%)	No. Expts.
1	0.1% N_2 mustard	2173	74	3.4	14
2	Ultraviolet	1383	225	16.2	14
3	0.1% Mustard + UV	3815	879	23.1	14
4	0.1% Mustard + pressure + UV	4056	1075	26.5	14
5	0.3% Mustard	656	67	10.2	3
6	0.3% Mustard + pressure	827	33	4.0	3

The results cited above would suggest that the changes observed with ultraviolet radiation and high pressure must be due primarily to the action of the pressure on changes that have already occurred in the chromosome at the time of pressure treatment, rather than that the latter prevents the reaction of a chemical mutagen with the chromosome. In other words, the delayed effects of ultraviolet irradiation are apparently not due to the production of a chemical mutagen which remains in the cytoplasm for as long as 20 min. Rather, the results suggest that the delayed effects are due primarily to semistable intermediates in the mutation process which require time for stabilization. The probability is still very great, however, that the initiation of a large number of these changes is due to the production of a chemical mutagen which rapidly reacts with the chromosomes as well as with other cellular components.

Additional evidence has been obtained concerning the characteristics of the semistable intermediate which occurs during and after treatment with a mutagenic agent. If such an intermediate were indeed formed, its decomposition would presumably be affected by temperature. Several experiments have been performed to test this, using both *Neurospora* and *Aspergillus*, and similar results have been obtained with both organisms. The results with *Aspergillus* are reported below. After the spores were treated for 30 min with 0.3% nitrogen mustard, the suspension was rapidly cooled and centrifuged. The spores were resuspended in sterile water and the suspension was divided into two fractions. One of the fractions was placed at 10° C and the other at 25° C. After 30 min at the respective temperatures, a sample of each was placed under pressure (10,000 psi) for 30 min. At the end of the pressure treatment all samples were plated, and individual colonies were subsequently isolated onto complete agar slants. At the end of 4 days the isolates were classified according to morphological characteristics. The results of several experiments are summarized in Table 4. It is evident that when the treated suspension is kept at 25° C (lines 3 and 4), pressure has no influence on the number of mutations when its application begins 30 min after the treatment with the mutagenic agent. On the other hand, if the treated suspension is kept at 10° C during this 30-min period (lines 1 and 2), pressure considerably lowers the number of mutants. The results suggest that some intermediate state is formed in the mutation process and that it thereafter decomposes to the final mutant state, the rate of decompositon de-

TABLE 4

EFFECT OF TEMPERATURE AND PRESSURE ON THE ACTIVATED STATES INDUCED BY NITROGEN MUSTARD IN *Aspergillus terreus*

No.	Treatment	Temperature 30 min (°C)	No. isolations	No. mutants	Mutation (%)	No. Expts.
1	0.3% N_2 Mustard	10	1755	213	12.2	5
2	0.3% Mustard + pressure	10	1465	107	7.3	5
3	0.3% N_2 mustard	25	1864	221	11.8	6
4	0.3% Mustard + pressure	25	1590	182	11.4	6

pending on the temperature. In addition, the significant effect of high pressure confirms the previous observations that these changes proceed with an increase in volume. The latter observations are of some importance, since they indicate that with pressure treatment the intermediate decomposes to the original, normal state, which cannot revert to the intermediate after the pressure is removed. In this respect, the results are quite similar to those obtained with ultraviolet treatment followed by high pressure.[2]

References

1. Riley, H. P., and Giles, N. H. *Genetics*, **35**, 131 (1950).
2. Swanson, C. P. *Proc. Natl. Acad. Sci. U. S.*, **35**, 237 (1949).
3. McElroy, W. D., and de la Haba, G. *Science*, **110**, 640 (1950).
4. Swanson, C. P., and Yost, H. T. *Record Genetics Soc. Am.*, **20**, 127 (1951).
5. McElroy, W. D., and Swanson, C. P. *Quart. Rev. Biol.*, **48**, 348 (1951).

[2] I would like to acknowledge the capable assistance of Mrs. R. Metcalf and Miss M. Ono in performing the experiments described in the present report.

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Localization of Protein-bound Radioactive Iodine by Filter Paper Electrophoresis

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The serum of an euthyroid patient with a Hurthle cell carcinoma of the thyroid with metastases was analyzed by filter paper electrophoresis, using a modification of the method of Kunkel and Tiselius (*1*), 1 hr after a dose of 40 mc of I^{131} and at daily intervals thereafter for 10 days. One tenth ml of serum was placed on two thicknesses of Whatman #3 filter paper strips held between glass plates. The ends of the paper strips were placed in veronal buffer, pH 8.6 and ionic strength 0.05. A current of 1 ma/strip was passed through at a potential of 300 v. At the conclusion of the electrophoresis, the bottom strip was stained with bromphenol blue, dried, washed with acetic acid, and cut into numbered strips. With the dye elution method the protein fractions were localized and their quantities determined. The top strip was cut into numbered segments, and the relative radioactivity determined in a bell-type Geiger counter.

The total protein-bound I^{131} after electrophoresis was compared with the total raidoactivity of a comparable amount of serum before electrophoresis. These values were identical after 3 days. The radioactivity was only 2% protein-bound after 1 hr and was freely distributed among all the serum proteins. At the end of 30 hr the radioactivity was 33% protein-bound, and there was definite evidence of concentration in the albumin and in the α-2 globulin. At 48 and 72 hr, the concentration at the latter site was more clearly evident. Over 80% of the activity was concentrated in and just beyond the α-2 globulin area at 72 hr and thereafter.

A typical radioelectrophoretogram of the 7-day serum is shown in Fig. 1, together with a graph of the

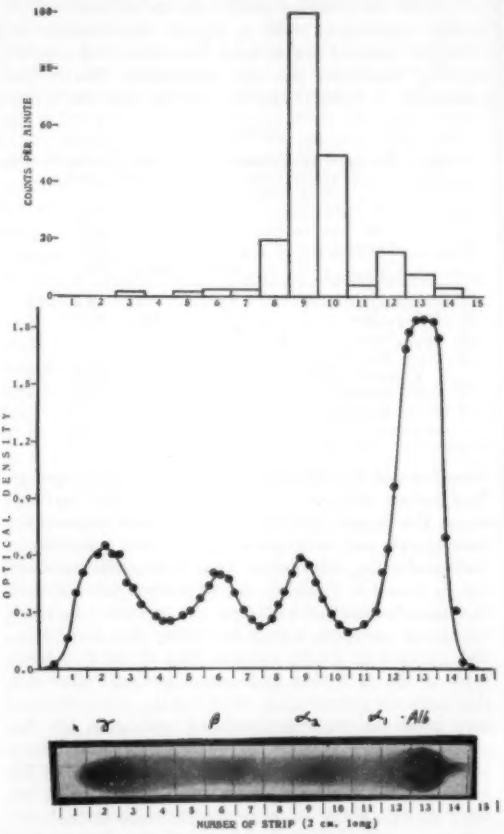

Fig. 1. Top graph shows the radioactivity of the 7-day serum on the segments of filter paper. Center graph shows the relative quantities of protein on similar segments. Photograph of the corresponding stained strip is shown at the bottom.

quantities of protein fractions as determined by the bromphenol blue elution method, and a photograph of the stained strip. The standard electrophoretic pattern of the same serum is shown in Fig. 2.

This method is reported as a new approach to the study of the nature of the circulating thyroid hormone as well as other substances which can be conveniently traced. It is not assumed that this is conclusive evidence of the behavior of normal thyroid hormone, since the subject under investigation had a carcinoma of the thyroid which was possibly in the functioning category. Some evidence that this serum was not completely normal can be seen in the standard electrophoresis in which a small abnormal peak is seen just beyond the α-2 area, especially in the ascending limb.

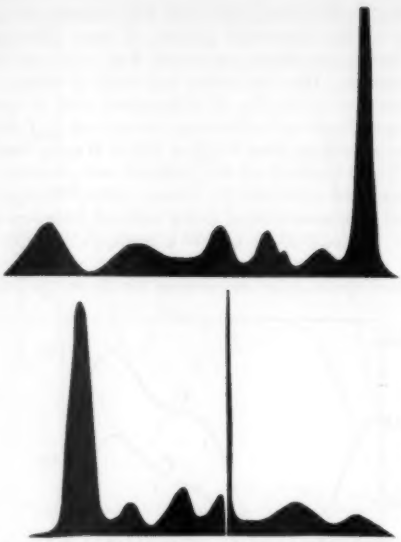

FIG. 2. Standard electrophoretic pattern of the 7-day serum. (Veronal buffer pH 8.6, ionic strength 0.1, 15 ma, 180 min.)

This peak is roughly in the area where the radioactivity localizes.

Reference

1. KUNKEL, H. G., and TISELIUS, A. *J. Gen. Physiol.*, **35**, 89 (1951).

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Relation of Chlorogenic Acid to Scab Resistance in Potatoes[1]

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The nature of the resistance of potatoes to common scab caused by *Streptomyces scabies* is not fully understood. Lutman and Cunningham (*1*) and Longree (*2*) attributed resistance to structural differences, whereas Kiessling (*3*) and Wingerberg (*4*) considered resistance to be based on physiological factors. Müller and Behr (*5*) suggested that substances giving typical tannin reactions are associated with resistance of potatoes to late blight caused by *Phytophthora infestans*. Walker *et al.* (*6*) found high concentrations of protocatechuic acid in skins of onion varieties resistant to the attacks of onion smudge, *Collitotrichum circinans*.

The presence of chlorogenic acid in potato tubers was first demonstrated by the use of $FeCl_3$. Phenolic compounds having the *ortho*-dihydroxy grouping give a green color with $FeCl_3$. In this test the epidermis of a tuber was carefully removed from a test spot, a drop of 5% $FeCl_3$ solution added, and the exposed tissue macerated with a sharp knife. The green color developed immediately, and its intensity varied with the resistance of the variety to scab. Nine named and 36 seedling varieties of potatoes of known scab resistance were given the $FeCl_3$ test. All varieties highly resistant to scab showed a strong color reaction when treated with $FeCl_3$. The intensity of the green color varied with the degree of scab resistance.

The identification of chlorogenic acid in the potato (*Solanum tuberosum*) was established by the use of paper chromatography and ultraviolet absorption techniques as described by Johnson *et al.* (*7*) in work on peach tannins. Only two phenolic compounds, chlorogenic acid and tryosine, were found to be present in significant quantities in potatoes. The $FeCl_3$ test indicated that chlorogenic acid was concentrated in a very thin layer, in the periderm perhaps not over 2 cells thick.

To demonstrate the presence of chlorogenic acid in the periderm of potato tubers, the following technique was used. One hundred grams of potato peelings, removed with a vegetable paring knife and having an average thickness of 1 mm, were extracted with 300 ml 95% ethanol in a Waring blendor for 5 min. The extract was filtered and concentrated to 25 ml under reduced pressure. This concentrate was then reduced to dryness in a vacuum oven at 35° C. The same procedure was used for the flesh of the potato. A 50-mg sample of the extract powder from the skin and flesh from two scab-resistant varieties, Russet Burbank and Yampa, was extracted three times with 5 ml petroleum ether in a 15-ml centrifuge tube to remove any fatty or waxy materials. The petroleum ether was decanted after centrifugation. The dry powder was dissolved in 0.5 ml water. Two µl was chromatographed on Whatman No. 1 filter paper using butanol-acetic acid-water (50-10-40) as a developing solvent. Fig. 1 shows a papergram after spraying with modified Folin-Denis reagent[2] and treating with ammonia fumes to alkalize the reagent. No. 1 shows separation of the tyrosine and chlorogenic acid. Nos. 2 and 4, from Burbank and Yampa skin extracts, respectively, show high chlorogenic acid but very low tyrosine content. The flesh extracts Nos. 3 and 5 reveal small amounts of tyrosine and a weak test for chlorogenic acid. Fluorescence of the papergram under ultraviolet light with maximum intensity at 3650 A also showed minute quantities of chlorogenic acid in the flesh. Fluorescence of the chlorogenic acid spot from the peeling extract was very pronounced. Fig. 2 shows the ultraviolet absorption spectra from Russet Burbank skin and flesh which were determined on a 50-mg sample of each dissolved in 200 ml distilled water after extraction with petroleum ether as described above. Spectrum No. 1 is typical for chlorogenic acid with high absorption at 324 mµ. Spectrum No. 2 has a strong

[1] Published with the approval of the director, Colorado Agricultural Experiment Station, as Scientific Journal Series Article No. 374.

[2] One part Folin-Denis reagent, 1 part water, and 2 parts 95% ethanol.

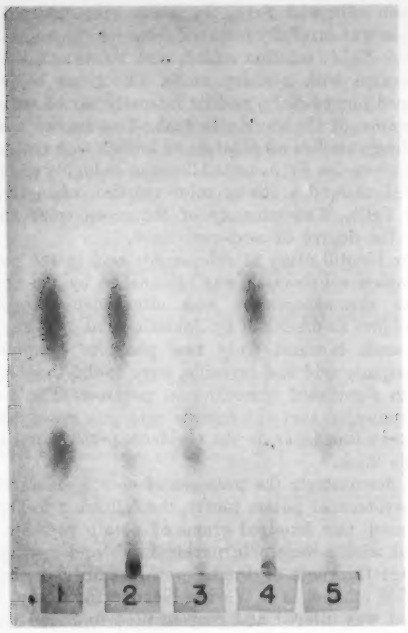

FIG. 1. Papergram sprayed with Folin-Denis reagent: No. 1, separation of chlorogenic acid and tyrosine; Nos. 2 and 4, extracts from Burbank and Yampa skins, respectively; Nos. 3 and 5, flesh extracts from Burbank and Yampa.

band at 268 mμ which is due to tyrosine. A very slight band at 324 mμ indicated traces of chlorogenic acid in the flesh.

One-dimensional paper chromatography, using the above developing solvent, was found to give good separation for chlorogenic acid. Fig. 3 shows the similarity of the ultraviolet spectra of pure chlorogenic acid and potato chlorogenic acid, both extracted from papergrams. This procedure was used as a basis for quantitative estimation of chlorogenic acid in potato peelings. These estimates were determined as follows: 100 g of peelings were weighed into a Waring blendor cup. Three hundred ml 95% ethanol was added to the peelings and extracted for 5 min. After filtration the extract was concentrated under reduced pressure until 50 ml was equivalent to 100 g peelings. Twenty aliquots of 2 μl were placed on a papergram in a row of adjacent spots. After developing for 20 hr, the papergram was dried. The fluorescent chlorogenic acid band was located under ultraviolet light, then removed from the papergram and eluted from the strip with 75% ethanol. The eluate (approx 1.5 ml) was made to 10 ml with distilled water. Optical density was determined at 324 mμ using a Beckman Model D. U. Spectrophotometer. $E^{1\%}_{1\,cm}$ at 324 mμ for anhydrous chlorogenic acid is given by Moores *et al.* (*8*) as 526.

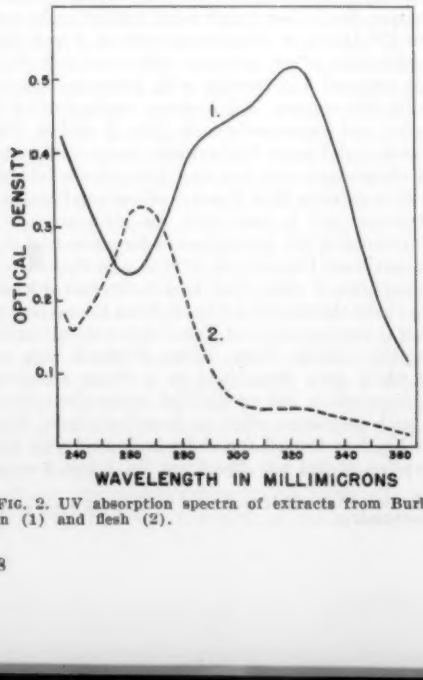

FIG. 2. UV absorption spectra of extracts from Burbank skin (1) and flesh (2).

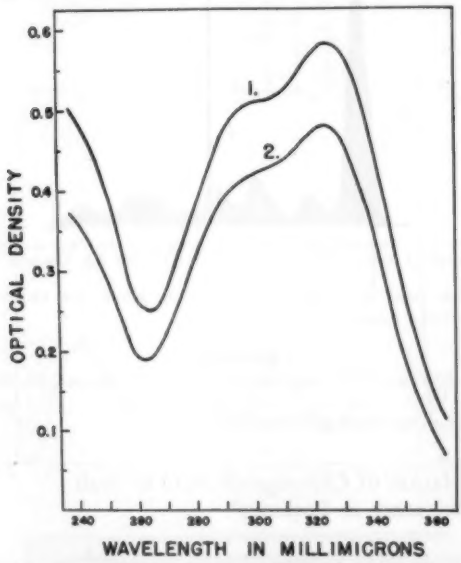

FIG. 3. UV spectra of pure chlorogenic acid (1) and potato chlorogenic acid (2). Both extracted from papergrams.

An unnamed USDA potato seedling highly resistant to scab, which gave a strong $FeCl_3$ test, contained 77 mg chlorogenic acid/100 g peelings of an average thickness of 1 mm. Since the chlorogenic acid is concentrated in a very thin layer, its actual concentration in individual cells was several times the above amount. A seedling variety highly susceptible to scab, which gave a weak $FeCl_3$ test, contained only 40 mg chlorogenic acid/100 g peelings. The ultraviolet absorption spectra of the peeling extracts of the above seedlings are shown in Fig. 4. Both extracts were prepared and diluted in the same manner. These spectral

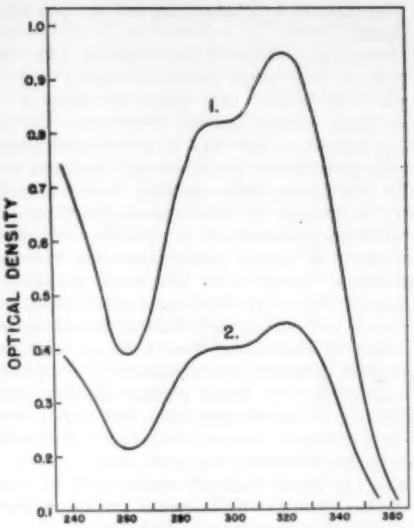

FIG. 4. UV absorption spectra of the peeling extract from a scab-resistant seedling (1) and from a scab-susceptible seedling (2).

curves likewise show much higher concentration of chlorogenic acid in the scab-resistant seedlings as compared to a scab-susceptible seedling.

The total amount of chlorogenic acid is not as important as the concentration in local areas. For example, in some scab-resistant potato varieties, the chlorogenic acid appears to be more heavily concentrated in or near the lenticels, which serve as the natural avenue of entrance for the scab organism. The $FeCl_3$ test also indicates that chlorogenic acid accumulates around a tissue injury, either mechanical or parasitic in origin. This observation, together with the fact that the concentration of the acid in the periderm varies with the degree of scab resistance, suggests that chlorogenic acid is involved in a protective mechanism. The exact nature of this protection has not been determined, but indications are that one or more mechanisms are involved.

It is possible that chlorogenic acid lowers pH of the cells, thereby creating an unfavorable medium for growth of the scab organism. Experiments indicate that when chlorogenic acid was added to unbuffered potato dextrose agar medium, the lowered pH was sufficient to retard growth of *S. scabies*. On buffered agar (pH 6.2) 400 mg chlorogenic acid/100 ml agar failed to retard growth of several physiologic races of *S. scabies*.

Since tyrosinase is also concentrated in the same area as chlorogenic acid, it may be that both are involved in a general protective mechanism. Chlorogenic acid is a good substrate for the polyphenolase fraction of tyrosinase. Upon tissue injury tyrosinase immediately oxidizes chlorogenic acid to the quinone which may be toxic to pathogenic organisms, and this would be in accord with views expressed by Szent-Györgyi and Vietorsz (*9*) as to a function of tyrosinase. The rate of quinone formation would vary with the concentrations of chlorogenic acid and tyrosinase. Quinone formation in the area where chlorogenic acid was concentrated was also found to be greater in the potato varieties resistant to scab. An acidified KI-starch solution was used as a test for quinone formation after macerating the tissue with a sharp knife.

Chlorogenic acid itself or its quinone may be directly or indirectly involved in the formation of cork cambium in a manner similar to action of the wound *hormone* traumatin as described by Bonner and English (*10*). This is believed true because chlorogenic acid added to a freshly cut surface of a tuber speeds up the production of suberized tissue.

References

1. LUTMAN, B. F., and CUNNINGHAM, G. C. *Agr. Expt. Sta. Bull. Vermont*, **184**, (1916).
2. LONGREE, K. *Arb. biol. Reichsanstalt Land-u. Forstw. Berlin-Dahlem*, **19**, 285 (1931).
3. KIESSLING, L. E. *Zentr. Bakt. Parasitenk.*, Abt. II, **89**, 177 (1933).
4. WINGERBERG, F. *Kühn-Arch.*, **33**, 259 (1932).
5. MÜLLER, K. O., and BEHR, L. *Nature*, **163**, 498 (1949).
6. WALKER, J., *et al. Proc. Natl. Acad. Sci. U. S.*, **15**, 845 (1929).
7. JOHNSON, G., *et al. Food Research*, **16**, (3), 169 (1951).
8. MOORES, R. G., *et al. Anal. Chemi.*, **20**, 620 (1948).
9. SZENT-GYÖRGYI, A., and VIETORSZ, K. *Biochem. Z.*, **233**, 236 (1931).
10. BONNER, J., and ENGLISH, *J. Plant Physiol.*, **13**, 331 (1938).

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A Modification of the Sudan Black B Technique for the Possible Cytochemical Demonstration of Masked Lipids[1, 2]

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The technique used in the study described here is an adaptation of a routine cytochemical method employed on blood films to demonstrate lipids. This modification is designed to reveal what are commonly called "masked" lipids not demonstrable by routine procedures. It involves the common use of Sudan black B, but on films previously treated with various organic acids.

The routine procedure for the demonstration of masked lipid in blood films is as follows:

1. Fix smears in formol vapor for 2–5 min.
2. Immerse fixed films in a 25% aqueous solution of acetic acid for 2 min. Citric acid (5%), oxalic acid (10%), or formic acid (10–25%) may be used in place of acetic acid.

[1] This investigation was supported by research grants from the National Cancer Institute of the National Institutes of Health, U. S. Public Health Service, and the Ohio Department of Health.
[2] Presented in part before The Ohio Academy of Science, April 28, 1950.

3. Wash thoroughly in tap water; wash in distilled water and allow films to dry.

4. Place dried films in a saturated solution of Sudan black B in 70% ethyl alcohol for 30 min. The Sudan black solution must be prepared at least 1 week prior to use.

5. Wash stained films with either 50% or 70% ethyl alcohol until excess Sudan black is removed. Wash immediately with water.

6. Blot films dry and mount with permount, glycerine, or glycerogel. Parallel control preparations are processed in the same manner except that the treatment with acid is omitted.

Fixatives successfully adapted for brief fixation of blood films and the demonstration of masked lipids are heat, formol vapor, osmic acid vapor, 10% formalin, formol-Zenker, mercuric chloride (1%), copper sulfate (0.5%), 1% formalin in 95% ethyl alcohol, methyl alcohol, and acetone. Bouin's solution, trichloracetic acid (20%), cobaltous nitrate (1%), and uranium nitrate (1%) should not be used in this procedure. Formol vapor is considered the fixative of choice because of the ease of fixation and also because it may be used as the fixative for a wide variety of cytochemical procedures performed on blood films.

Lipids have been unmasked by four carboxylic acids (formic, acetic, citric, and oxalic acids), but cannot be unmasked by mineral acids (1 *N* hydrochloric, 1 *N* sulfuric, 1 *N* nitric, 0.5% periodic, and carbonic acids). Hydrochloric acid prepared at pH 1, 2, 3, 4, 5, and 6 failed to unmask any sudanophilic material in blood cells, and the more acidic solutions, pH 1 and 2, prevented the lipid normally demonstrated in control preparations from staining. Weak bases (saturated solutions of calcium hydroxide and lithium carbonate and 10% ammonium hydroxide) and strong base (1 *N* sodium hydroxide) failed to unmask cellular lipid.

Sudan black B prepared in 70% ethyl alcohol, 40% ethyl alcohol, ethylene glycol, and 50% acetone may be used in the procedure described, although it must be noted that the staining reaction and color of control preparations is different, depending upon the solvent used.

TABLE 1

EFFECT OF VARIOUS LIPID SOLVENTS AND PROTEOLYTIC ENZYMES ON THE NUCLEAL AND MODIFIED SUDAN BLACK REACTIONS

Solvent and enzyme	Nucleal reaction	Acetic acid–Sudan black reaction
Control	++++	++++
Alcohol-ether (2:1)	++++	–
Acetone	++++	+
Desoxyribonuclease (0.1 mg %)	–	–
Trypsin (1%)	+	+
Pepsin (1% in 0.1 *N* HCl)	±	+
Sodium chloride (1 *M*)	++	++
Distilled water	+++	+++

+ Indicates the relative intensity of the reaction following digestion for 24 hr in the above substances as compared with undigested control (++++) preparations.
– Indicates no reaction.

A comparison of blood films stained with Sudan black B in 70% ethyl alcohol (control) and films treated with acetic acid prior to staining with Sudan black reveals marked differences. The most striking differences are: (1) in acid-treated preparations the nuclei of the leucocytes and nucleated erythrocytes are sudanophilic, staining brown to yellow-brown, in contrast to their sudanophobic nature in control Sudan preparations; (2) platelets only slightly sudanophilic in control preparations are moderately sudanophilic (brown with blue-black granules) in acid-treated films; (3) black sudanophilic granules of neutrophils and monocytes in control preparations are not evident in acid-treated films, although many small sudanophilic granules are unmasked in lymphocytes and monocytes; (4) blood plasma appears slightly sudanophilic in acid-treated films, but is not evident in control preparations; (5) erythrocytes are rendered sudanophobic following acid treatment.

Cohen (*1*) found that cell nuclei could be stained with Sudan black to which organic acids were added; he believes that the organic acid dye solutions are simply nuclear stains. Leach (*2*) considers the brown dye formed by the addition of diacetin to Sudan black ("mucisudan") to be a stain for mucin.

Table 1 illustrates the effect of various proteolytic enzymes and lipid solvents on the sudanophilic and desoxyribonucleoprotein components of the cell nucleus as demonstrated by the acetic acid–Sudan black technique and the nucleal reaction, respectively.

The lipid nature of the sudanophilic material is suggested by the solubility of this component in alcohol-ether, hot pyridine, and partial solubility in acetone, as well as the insolubility of the desoxyribonucleoprotein with these solvents. The possibility of the lipid existing as a lipoprotein complex, perhaps a lipo-nucleoprotein complex, is indicated by the solubility of the sudanophilic component by various proteolytic enzymes, including desoxyribonuclease. It was impossible to unmask the sudanophilic material of the cell nuclei with the substances indicated in Table 1.

Further evidence supporting the view that lipids are unmasked and demonstrated by the technique described include the following observations: (1) Biochemical studies (*3*) on nuclei reveal that they contain considerable quantities of lipid, principally phospholipids (sphingomyelins or saturated lecithins or cephalins) and cholesterol. The phospholipid content of the nuclei is suggested by this Sudan technique and the extraction experiments. (2) Platelets contain a considerable amount of phospholipid (15% dry weight), principally cephalin. Phospholipid and plasmalogen may be demonstrated cytochemically in blood platelets as determined by Baker's acid haematin test (*4*) and the plasmal reaction (*5*), respectively. However, platelets, sudanophobic after staining with alcoholic Sudan black, may be readily demonstrated in organic acid–treated films. (3) The phospholipid content of lymphocyte mitochondria may be demonstrated

cytochemically (*5*); however, although lymphocyte mitochondria stain only very slightly with alcoholic Sudan black, following acid treatment their staining reaction is markedly enhanced. (4) Plasma lipids are unmasked by acid treatment, although a longer fixation time (i.e., 5 min) is necessary.

It is generally considered that lipids stain blue or black with a 70% alcoholic solution of Sudan black. Therefore, this technique may be criticized because a brown color is obtained in certain cellular components (nuclei and platelets) after acid treatment. This objection is minimized by the observations discussed above, as well as by several additional facts: (1) Sudan black prepared in 40% ethyl alcohol yields a brown solution; in 70% alcohol the solution is blue-black. Although the distribution and amount of sudanophilic material present in cells are identical after staining with these solutions, the color is different (brown with a 40% dye solution and black with a 70% dye solution). A similar color difference is obtained in the liposomes of the rat adrenal gland, as well as in adipose tissue (frozen sections). (2) The sudanophilic rim of the blood eosinophil granule is considered to be lipid (*4*), although it stains brown rather than black in control preparations stained with 70% alcoholic Sudan black.

The lipids of the mitochondria and blood platelets may be unmasked more readily using more dilute acid solutions than can the lipid of the nuclei. The differences in the color of the nuclei, platelets, and mitochondria following acid treatment and staining with Sudan black are suggestive of a difference in the type or form of phospholipid or lipoprotein complex. The mechanism by which lipid is unmasked by weakly ionizable acids is not known. However, the acids may act by dissociating or splitting the lipoprotein complexes and allowing the lipid to be accessible to the dye.

References

1. COHEN, I. *Stain Technol.*, **24**, 177 (1949).
2. LEACH, E. H. *J. Path. Bact.*, **47**, 637 (1938).
3. STONEBURG, C. A. *J. Biol. Chem.*, **129**, 189 (1939).
4. BLOOM, M. L., and WISLOCKI, G. B. *Blood*, **5**, 79 (1950).
5. ACKERMAN, G. A. Unpublished data.

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Comments and Communications

Common Names for Subspecies in Zoology

INEVITABLY, the science of one's own time seems somehow different in quality from the science of the past. No doubt Linnaeus's teacher, Olof Rudbeck the Younger, in the early 1700s, had the same feeling when he looked back on the science of Conrad Gesner; and Gesner himself must have felt the same way as he contemplated the works of Pliny. When we read the history of science with a discerning eye, we realize, perhaps with some surprise, that to students in the far future (if there are any) the apparently solid and sober structure of our contemporary science will be seen to be shot through with obvious errors and absurdities.

One of the latter—a minor one to be sure—will probably be the present fad of giving so-called common names (in reality, usually mere book names) to every subspecies of animal described by naturalists. The writer, be it understood, has no quarrel with standardized common names for easily recognizable and valid species. In a relatively few instances, such as that of the Common Canada Goose and the Cackling Goose, it would seem to be proper to assign common names even to subspecies. Neither does he question the necessity for giving *technical* names to valid subspecies. What he does object to as unnecessary and even ridiculous is the current fashion of publishing such names, to take a fanciful example, as Rufous-crowned Gray Dinglebat, Purple-sided Gray Dinglebat, Southern Plains Dinglebat, and Smith's Dinglebat for, let us say, four subspecies of critters which everyone has for generations called simply Gray Dinglebats, and which nobody but a specialist on dinglebats can tell apart anyway.

To take one real example, from the multitude available, in the serpent fauna of New Mexico *Pituophis catenifer* is known to all and sundry in my part of the country as the Bull Snake. In New Mexico there are three recognized subspecies of this snake—*P. sayi*, *P. affinis*, and *P. deserticola*. In the recently issued second edition of C. B. Perkins's *Key to the Snakes of the United States*, a standard reference work, I find these listed, respectively (p. 9), as Bull Snake, Sonoran Gopher Snake, and Great Basin Gopher Snake. Yet nobody but an ophiologist can tell them apart, and to the average English-speaking person in New Mexico they remain simply Bull Snakes. Biologists, likewise, almost always use the scientific names or just call the animals Bull Snakes. Possibly biologists farther west call them Gopher Snakes, but the principle is the same. Who, then, is supposed to use these complicated common names? And what about the individuals of *P. catenifer* in areas (extensive, be it noted) where *P. sayi* and *P. affinis* intergrade? If we accept the above-mentioned trinomial system of common names, these unlucky intergrading individuals are neither "bulls" nor "gophers" and presumably have no common name at all. Furthermore, turmoil is added to confusion when we note with dismay that Schmidt and Davis in their widely used *Field Book of Snakes of the United States and Canada* (p. 163) call Perkins' *P. c. affinis* the Arizona Bull Snake in-

stead of Sonoran Gopher Snake. The fact that since 1941, when the *Field Book of Snakes* was published, systematists have reduced *sayi* from a full species to a subspecies does not seem to justify a Bull Snake suddenly becoming a Gopher Snake, at least in common parlance.

Would it not be better, in works intended for the intelligent section of the general public, to list all the subspecies of *P. catenifer* simply as "Bull Snake or Gopher Snake," being content to let each person make his own choice, depending on local usage in his area? The principle is widely applicable.

Smith and Kennedy (*Herpetologica*, 7, [3], 93 [1951]) have recently proposed that *P. catenifer* be merged with *P. melanoleucus*, the Pine Snake. Should this proposed change in nomenclature win acceptance, fresh difficulties in the matter of common names within the genus appear certain to arise just as soon as compilers and revisers of general manuals catch up with the change. This prospective situation further emphasizes the desirability of trying to keep common names truly common, and of refraining from coining them where they do not already exist in actual use. If this recommendation were followed, new, common name difficulties would not arise whenever the systematists revise their schemes of classification.

Nomenclature is fundamental to an orderly knowledge of any faunal group, so let us by all means have recognized names, including standardized common names; but let us also have common sense along with them.

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Problems Involved in a World-Wide Soil Survey

WITH the increasing realization of the important part that certain metallic elements, present in trace concentrations in soils, play in plant, animal, and human nutrition, it is but natural that suggestions should be made for a world-wide soil survey in order to determine the extent and location of deficiencies. This is the subject of a short article by K. Starr Chester entitled "Trace Minerals in Food Production and Health" in this journal (SCIENCE, 115, 3 [Jan. 11, 1952]). He has discussed the project in general terms, pointing out the advantages of a central laboratory employing spectrographic methods for the chemical analyses. This is unquestionably our most efficient tool for such a survey, but I would like to discuss some of the practical considerations of time, instruments, and personnel involved in such a program.

The nonmetallic minerals of which soils are composed require the carbon arc as the source for spectrochemical analyses. Such considerations as ease of handling and representativeness of sample indicate a sample weight of 10–20 mg. A sample of this size requires an exposure of about 2.5 min, so that about 25 can be exposed in 1 hr. This figure determines the maximum output of the spectrograph. For such a routine a laboratory crew of about 8 is needed, for such operations as preparing the samples and electrodes, attending the spectrograph, measuring, and calculating. For the field work of collecting, quartering down, and dispatching of samples, a unit of 3 should be able to handle about 50 samples/day, or a total of 12 people for the 200 samples required each day. For personnel, therefore, a total of 20 is needed to serve one spectrograph for each 8-hour day. For maximum use of the laboratory, operations should be on a two-shift basis; this will double production to 2,000/week, or 100,000 samples/year, with a working force of 40.

At this point an estimate must be made of the average sampling density, which, as we do not yet know the degree of variability of the trace element concentrations, must be a guess. Too high a density would be wasteful of time and labor; too low would endanger the worth of the whole survey. It would vary with locality, and adjustments will be made as data accumulate. Assuming, therefore, a density of 1 sample/5 acres, the annual output of one spectrograph will then survey half a million acres.

In the continental U. S. there are approximately 350 million acres in crops alone, excluding pasture, woodland, and forest. Working with one spectrograph, therefore, this limited survey will require 700 years! Obviously, we must enlarge our thinking on this problem; what is required is not a small group operating one or two spectrographs but a huge establishment of a thousand people operating a battery of 20 or 30 instruments, with costs running to several million dollars per year.

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An Improved Moist Chamber

BIOLOGISTS make frequent use of moist chambers in the course of their investigations. The usual moist chamber consists of 2 loosely fitting glass dishes superimposed upon each other to form a closed chamber, which is humidified by lining the bottom of the lower dish with wet filter paper, paper toweling, etc. Mycological investigations carried out by the writer have been hampered by the ability of fungi and bacteria to contaminate otherwise isolated test specimens by growing across the dampened surface.

This difficulty has been overcome by using cellulose sponge yarn[1] as the humidifying agent. This material is made up of cellulose sponge molded in a circular cross-sectional pattern around a solid core and extended into various lengths. The yarn has a high water-holding capacity and is easily cut and handled. A piece of yarn can be arranged around the inner wall of the moist chamber bottom clear of free water. Water may be added to the yarn periodically to main-

[1] This yarn was provided for experimental purposes by the Film Division of E. I. du Pont de Nemours & Company, Inc., Wilmington, Del.

tain the desired humidity in the moist chamber, and the yarn may be reused after sterilization.

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Dissa and Data

FOR nearly 20 years I have recommended to students my opinion that (1) the word "data" should be related to a plural verb form, as "the data are;" and that (2) the word "disinterested" means impartial or unbiased.

If recent publications are evidence of common usage, "data" can be used with either singular or plural verb form. It appears that this is a result of "growing pains" of our language. Are we all agreed to accept?

"Disinterested" has been often used recently in place of "uninterested." To this I object—probably ineffectually. "Disinterested" was a useful word, and I do not like losing it.

Shall I continue my former practices of instruction, or shall I stop being a bigot and forget?

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EDITORIAL NOTE: *The editors subscribe to Dr. Warren's bigotry and will continue to correct these errors whenever they are made in manuscripts. They also object to the use of "presently" for "now," and "while" for "whereas" or "although." They are also disturbed because of (not "due to") the adverbial misuse of the adjectival expression "due to."*

Book Reviews

Taxonomy of Vascular Plants. George H. M. Lawrence. New York: Macmillan, 1951. 823 pp. $7.95.

Modern botanical research has repeatedly substantiated the old taxonomic practice of treating the vascular plants as a major unit. Although many manuals and floras contain descriptions of all vascular plants found in a given area, they are rarely treated together in textbooks of systematic botany. Actually, *Taxonomy of Vascular Plants* is the first modern textbook of this kind and is eloquent testimony of the present tendency toward dealing with all vascular plants under the name Tracheophyta. Yet the author deliberately adopted the last published version (1936) of the widely used Engler system of classification, with its obvious shortcomings, as the basis for the systematic section of the book (Part II, pp. 333–72), because it is still the most carefully elaborated system available.

Other conspicuous changes in comparison with existing texts of systematic botany are seen in the elimination of all floral diagrams and formulas, the replacement of chapters dealing with the organography of vascular plants by an illustrated glossary of taxonomic terms (Appendix II, pp. 737–75), the introduction and consistent use of the term "taxon" (taxa), and the consolidation in Part I (pp. 1–331) of 14 chapters on "Principles and Practices of Plant Taxonomy." Appendix I (pp. 733–36) represents a "Suggested Syllabus for an Elementary Course in Taxonomy" for those who wish to use the book as a text in a one-term course. This syllabus proves that it is much more than an elementary textbook in both scope and contents. Thus it is not only the most inclusive textbook of systematic botany in English (or any other language) but also a convenient and indispensable reference work for the advanced student. The latter will find in it well-balanced discussions of all major controversial aspects of phylogeny, along with informative chapters on field and herbarium techniques and other important principles and practices of taxonomy currently in use. The same is true of the systematic part with its enumeration of 264 families of vascular plants "known to grow as indigens or exotics in North America north of Mexico." The account of each family includes a technical description, enumeration of important genera, distributional data, discussion of morphological characteristics and assumed phylogenetic relationships, key references, and representative figures, many from L. H. Bailey's *Manual of Cultivated Plants* (1949). Completely extinct groups like the Pteridospermae are excluded.

A few interesting details may be singled out for comment. Under Ginkgoaceae five of the seven references deal with the spelling of the generic name *Ginkgo*, which should be corrected to *Ginkyo*. The future alone will tell how soon and how widely this spelling will be accepted. It is regrettable, however, that so much attention is being given to a problem of nomenclature when this important taxon is in such dire need of a synoptic treatment of its fossil forms. The recently proposed family Sarcopodaceae, here provisionally listed under the Gnetales (p. 368), has been rescinded, now that the genus *Sarcopus* has been identified with *Exocarpus* (Santalaceae). The Compositae are regarded as the largest family, with 950 genera and 20,000 species, thus rivaling or exceeding the Orchidaceae, here credited with 450 genera and 10,000–15,000 species, but considered to be the largest family by other authorities. Most likely, both families are larger than the remainder, containing numerous species, many of which may prove to be referable to others once critical studies of large genera are carried out.

In the light of the contents, fine typography, and illustrations, the price of this scholarly book is moderate, enabling taxonomists to own copies. Botanists in need of taxonomic information will find it an invaluable guide and source.

THEODOR JUST

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Phase Transformations in Solids. Symposium held at Cornell University, August 23–26, 1948. Sponsored by the Committee on Solids, Division of Physical Sciences, the National Research Council. R. Smoluchowski, J. E. Mayer, and W. A. Weyl, Eds. New York: Wiley; London: Chapman & Hall, 1951. 660 pp. $9.50.

This handsome, well-printed volume resulted from a symposium at Cornell University on the subject indicated in the title. The symposium was organized by the National Research Council for the purpose of bringing together physicists, mineralogists, and metallurgists, to discuss a topic of common interest. The topic is one that appears easy on casual approach, but becomes harder as the bewildering variety of facts is passed in review. It is not surprising, in view of this, that the three groups of scientists have developed a slightly different slant on the same problem. Among these points of view, the crystallographer's appears the most mature. The physicist proposes and tears down his theories somewhat too quickly to be taken seriously, and the material accumulated by the metallurgist is lacking in scientific precision. Indeed, one mineralogist remarked somewhat sarcastically during the conference that the only crystal planes the metallurgists seem to have heard of are the 100, the 110, and the 111 planes.

The first few articles deal with the more profound aspects of equilibrium theory, and a middle section deals with phase diagrams, but the greater part of the book deals with rate-determining mechanisms such as diffusion or nucleation. In the experimental work concerned with these questions it is hard to come to clear formulations; hence, the material accumulated tends to become bulky.

In spite of the number of contributing experts, it seems to this reviewer that the book does not quite correspond to the effort that went into it. In the first place, the book appeared late: almost three years elapsed between the symposium and its appearance. It is true that several papers were partially or completely rewritten to take care of recent developments. But this can only partly remedy an unhappy situation. A conference report is most useful in the period immediately following the conference, when the scientists working in the field are trying to orient their thinking. With a delay of three years, research workers in the field must have turned to other sources of inspiration.

When the book is considered as a reference work rather than as a conference report the delay is obviously much less important. However, it suffers then from other defects. A record in book form of even a successful conference does not make a first-rate handbook. Some speakers have justifiably taken a personal approach, others have written a survey article of recent work, giving all viewpoints. A person consulting such a volume in a library would probably be best served by a handbook-type article—that is, a survey limited to the work judged good by the author, but with a tolerant viewpoint and without discrimination between the old and the new. Such books would need centralized editorship, with an index at the end and clear division between the sections. The need for them becomes more urgent every year. The great German physics handbooks are now 20 to 30 years old and need replacement badly. If the National Research Council could sponsor such books it would earn the gratitude of every scientist.

GREGORY H. WANNIER

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Finite Deformation of an Elastic Solid. Francis D. Murnaghan. New York: Wiley; London: Chapman & Hall, 1951. 140 pp. $4.00.

This book is apparently intended to serve as a text, rather than as a treatise for research workers. The author regards the treatment as elementary. Matrix methods are used throughout, and the pages are dense with calculations.

After some classical results on the general theory of elasticity the author expands the strain energy in a power series, which he truncates after the cubic terms; the remainder of the book (with one exception presently to be noted) is devoted to this second approximation theory. The special forms assumed by the cubic terms for the various types of crystals are determined. There follow treatments of simple shear both for isotropic and for a certain aeolotropic material, simple tension, compression of a spherical shell and cylindrical tube, and torsion of a circular cylinder. The exception to the method of power series expansion is the treatment of hydrostatic pressure, where the author obtains what he calls an integrated linear theory by assuming that the ordinary linear elastic coefficients are linear functions of pressure.

Although the author's various approximate formulas may be useful in certain applications concerning moderate strains, it is unfortunate that his book makes no mention of the more fundamental recent researches in finite elasticity theory by Rivlin and others, where the form of the strain energy is left arbitrary and results, directly and successfully comparable with experiments on very large strain of rubber, are calculated in full generality.

C. A. TRUESDELL

Institute for Applied Mathematics
Indiana University

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By Cecil Stewart, Manchester College of Art. Concise, well-illustrated history of city planning from Greece to modern Britain, citing social and economic conditions which led to founding new towns and cities; lively human interest. Ready, June. 208 pages. 28 pages of plates; 20 pages of figures. About $5.00.

Lewis

EDWIN CHADWICK and the Public Health Movement

By Richard A. Lewis, University College of North Wales. Based on Chadwick's hitherto unused private papers, covers findings of the British Poor Law Commission of 1832–48, and the work of the General Board of Health of 1848–54, showing conditions and improvements in sanitation, nutrition, housing, and medical services. Ready, September. 408 pages. Frontispiece. About $4.75.

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Publications Received

Condensed Review of Pharmacy Specially Adapted to College of Pharmacy Students. 7th ed. George W. Fiero. New York: Wiley; London: Chapman & Hall, 1952. 122 pp. $3.25.

Host Relationships of Moths of the Genera **Depressaria** ***and*** **Agonopterix,** ***with Descriptions of New Species.*** Smith. Misc. Colls., Vol. 117, No. 7. J. F. Gates Clarke. Washington, D. C.: Smithsonian Institution. 20 pp.+ 6 plates. (No price given.)

Practical Radiography for Industry. H. R. Clauser. New York: Reinhold, 1952. 301 pp. $7.50.

A Racial Study of the Pacific Mackerel, **Pneumatophorus diego.** State of Californin Department of Fish and Game Bureau of Marine Fisheries Fish Bull. No. 84. Phil M. Roedel. San Pedro: Calif. Dept. Fish and Game, 1952. 53 pp. Illus.

Research and Industry, Partners in Progress. 1951. Annual Report Stanford Research Institute. Stanford, Calif.: Stanford Research Institute, 1951. 49 pp. Illus.

Simplified Arithmetic for Nurses. M. Esther McClain. Philadelphia–London: Saunders, 1952. 151 pp. $2.00.

Standard Values in Blood. AF Technical Report No. 6039. Errett C. Albritton, Ed. Prepared under the Direction of the Committee on the Handbook of Biological Data, American Institute of Biological Sciences, National Research Council. Dayton, Ohio: U. S. Air Force, Wright Air Development Center, Wright-Patterson Air Force Base, 1951. 199 pp. Illus. (No price given.)

Steps Toward Prevention of Chronic Disease. Summary of the National Conference on Chronic Disease: Preventive Aspects. Raleigh, N. C.: Health Publications Institute, Inc., 1952. 31 pp. 50¢.

Studies of Slab and Beam Highway Bridges. Part III. ***Small-Scale Tests of Shear Connectors and Composite T-Beams.*** Univ. Ill. Engin. Expt. Sta. Bull. Series No. 396. C. P. Siess, I. M. Viest, and N. M. Newmark. Urbana: Univ. Ill., 1952. 135 pp. Illus. $1.00.

Technical Cooperation with Underdeveloped Countries. Philip C. Newman, John E. Ullmann, and Robert S. Aries. New York: Chemonomics, 1952. 97 pp. $5.00.

Technology and History. L. T. Hobhouse Memorial Trust Lecture No. 21. Charles Singer. New York: Oxford Univ. Press, 1952. 19 pp. 60¢.

Townsman's Food. Magnus Pyke. London: Turnstile Press, 1952. 212 pp. 15s.

The Utilization of Sugar Cane Bagasse for Paper, Board, Plastics, and Chemicals. 2nd ed. An Annotated Bibliography. Compiled by Clarence J. West. New York: Sugar Research Foundation, Inc., 1952. 200 pp. Free.

Variation in Some Unarmed Hymenolepididae (Cestoda) from Rodents. Univ. Calif. Pubs. in Zoology, Vol. 57:1. Marietta Voge. Berkeley and Los Angeles: Univ. Calif. Press, 1952. 51 pp. Illus. 75¢.

Water Temperatures of the Willamette River Basin, 1950. Special Scientific Report: Fisheries No. 69. Kingsley G. Weber and Lyle G. Schedin. Washington: U. S. Dept. Interior, Fish and Wildlife Service, 1952. 25 pp. Mimeo.

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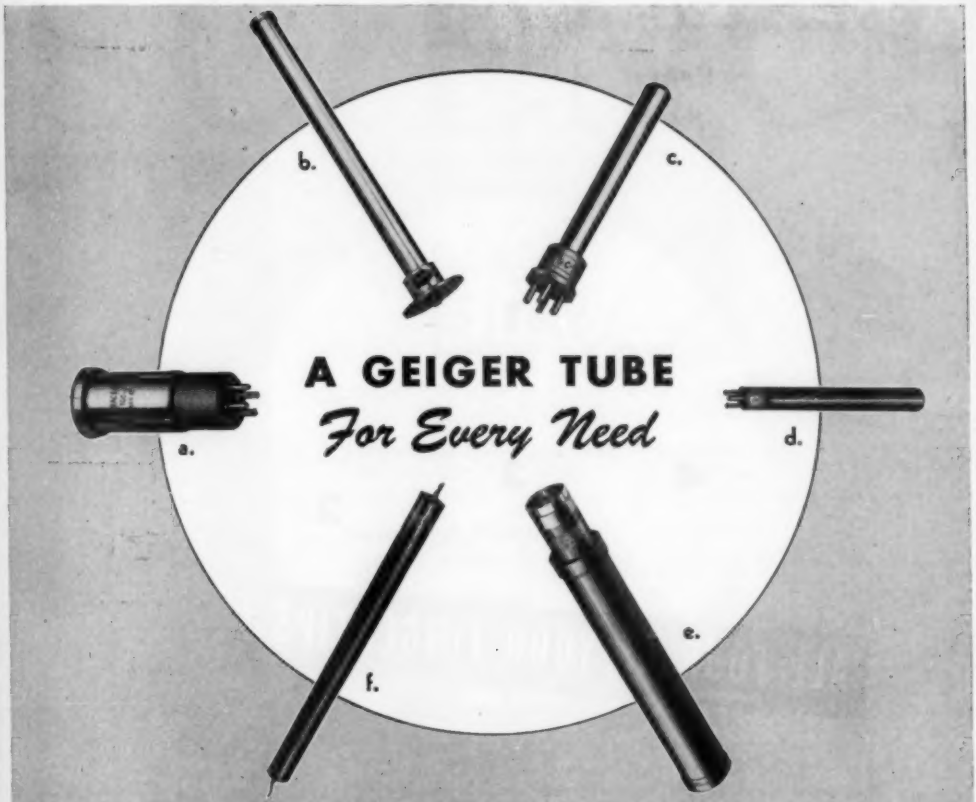

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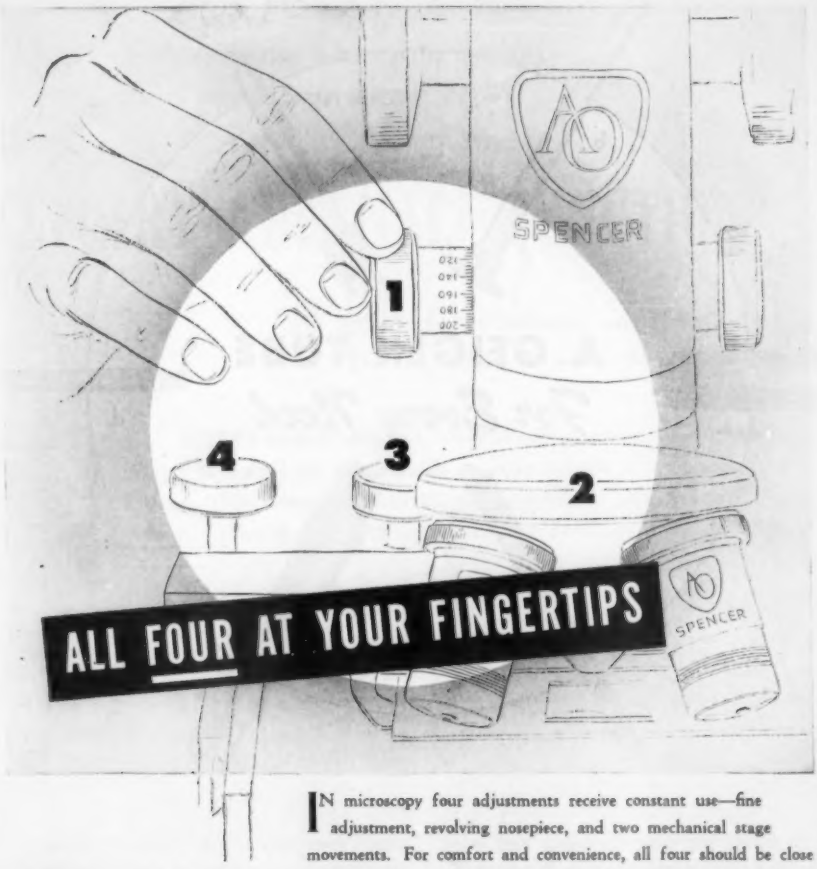

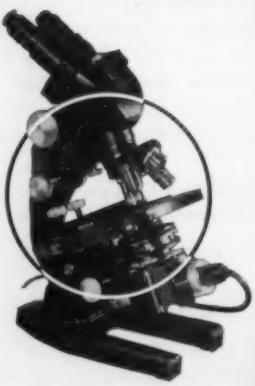

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